

AN ANALYSIS OF PERIODIC RHYTHMIC STRUCTURES IN THE MUSIC OF
STEVE REICH AND GYÖRGY LIGETI

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The compositions of Steve Reich and György Ligeti both contain periodic rhythmic structures. Although periods are not usually easily perceived, the listener may perceive their combinations in a hierarchy of rhythmic structures. This document is an attempt to develop an analytical method that can account for this hierarchy in periodic music.

I begin with an overview of the features of Reich's and Ligeti's music that contribute to the property of periodicity. I follow with a discussion of the music and writings of Olivier Messiaen as a precedent for the periodic structures in the music of Reich and Ligeti. I continue by consulting the writings of the Israeli musicologist Simha Arom and describing the usefulness of his ideas and terminology in the development of my method. I explain the working process and terminology of the analytical method, and then I apply it to Reich's *Six Pianos* and Ligeti's *Désordre*.

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CHAPTER 1

“ENOUGH MYSTERIES TO SATISFY ALL”: AN INQUIRY INTO THE INTERACTIONS OF SUPERPOSED RHYTHMIC STRUCTURES

Through a direct statement of his aesthetic preferences in “Music as a Gradual Process,” Steve Reich identifies one of the most fascinating aspects of his music:

The use of hidden structural devices in music never appealed to me. Even when all the cards are on the table and everyone hears what is gradually happening in a musical process, there are still enough mysteries to satisfy all. These mysteries are the impersonal, unintended, psycho-acoustic by-products of the intended process.¹

These “mysteries” are the catalysts for my inquiry into how a listener perceives the interactions of superposed rhythmic structures. From my experiences as a listener I recognized the need for a cognitive process to organize the interactions of rhythmic layers I heard. I heard these interactions as independent aural objects, and I was motivated to formulate an analytical method to account for them on multiple levels. Specifically, I sought to clarify their characteristics, their relationships to one another, and their structural role in the greater context of a composition.

New Listening Strategies for the Music of Steve Reich

I first noticed these interactions in the music of Steve Reich. When I listened to his music, I noticed that the different layers of musical material yielded patterns that existed in the notation but were not emphasized by the composer. This combination created a wealth of secondary material that sounded different with each listening.

¹ Steve Reich, “Music as a Gradual Process” in *Writings about Music* (New York: New York University Press, 1974), 10-11.

My experience with the “by-products” in Reich’s music required me to change my listening approach. I had become accustomed to the harmonic conventions of the late nineteenth- and early twentieth-century Western tonal repertoire, in which there are expected patterns of tension and repose that arise from harmonic activity. Listener expectations are lured, foiled, and fulfilled within the large-scale interplay between tonic and dominant. However, Reich’s music requires a different listening strategy because harmonic tension and repose are absent.

In Reich’s music, triadic harmonies are often present, but they are subservient to slowly unfolding rhythmic processes. As a result, Reich’s pieces are highly repetitive with a very slow rate of change. Reich’s music, with its repetitions and gradual changes, is really an extended aural moment in which the listener is given the chance to inspect every niche of the musical object, much like an observer of an almost imperceptibly rotating sculpture can grasp every detail with ultimate clarity.

Reich creates extended aural moments by imposing various processes on simple patterns. Ironically, these processes create an almost endless variety of aural by-products for the listener’s directed attention to define. Reich later referred to these “psycho-acoustic by-products” as “resulting patterns”:

Resulting patterns are melodic patterns that result from the combination of two or more identical instruments playing the same repeating melodic pattern one or more beats out of phase with each other.²

In pieces such as *Drumming* and *Six Pianos*, Reich collaborated with the performers in the selection of resulting patterns to double against the overall texture. The fact that two different groups of performers associated with *Drumming* heard different groups of

² Steve Reich, “Some Thoughts about Performance,” *Contemporary Music Review* 7 (1992): 41.

resulting patterns is a testament to the many possibilities that arise from pattern combinations.³

Canonic structures are at the root of these complexities. In fact, Reich states that his compositional practice is essentially the creation of canons.⁴ All of his subsequent ideas flow from this technique.

The technique I first discovered in 1965 while working with tape loops I called ‘phasing.’ It was later, in 1967, applied to live performance. In fact, ‘phasing’ is a process for composing canons at the unison where the subject is short and the rhythmic interval between the subject and its answers is variable.... Though I stopped working with the phasing technique in 1971 after *Drumming*, I found other ways to gradually build up canons at the unison between two or more identical repeating patterns. The most productive of these is to gradually substitute notes for rests—sound for silence—until a canon is constructed.⁵

Rhythmic construction (the gradual substitution of notes for rests mentioned above) and phasing are simply different ways of constructing a canonic relationship between two or more voices. By creating canons through phasing and rhythmic construction, Reich is able to ensure the viability of lengthy compositions based on the repetition of short motives.

Similarities Between the Music of Steve Reich and György Ligeti

As I was studying some of Reich’s compositions with Howard Meltzer, he suggested to me that the piano etudes of György Ligeti were similar to Reich’s work. Specifically, he directed me to Ligeti’s first etude, *Désordre*. I noticed that several aspects of *Désordre* were indeed similar to Reich’s practice: the audible eighth-note pulse, canonic relationships, periodic motives and rhythms, and resulting patterns.

³ Ibid., 41.

⁴ Steve Reich, “Texture-Space-Survival,” *Perspectives of New Music* 26 (1988): 273

⁵ Ibid., 272.

With these similarities in mind, I began this project as a comparison between the music of Reich and Ligeti. However, the more I scrutinized their music, I realized that an analytical method did not exist that could explain the rhythmic phenomena. These phenomena suggested a need for a method that could identify, categorize, and clarify the interactions between periodic structures. I will apply such a method to the music of these two composers to test its usefulness beyond a single composer's style. Such a method should be flexible enough to account for the practice of any composer that uses periodic structures.

I also see the need for an analytical method that relates directly to what the listener hears. The question may arise, "Who is the listener?" For the purposes of this study, I will draw from my own observations. Listeners engage music in different ways, and my study is not an effort to account for these differences. Rather, I will use my observations to demonstrate how someone might proceed to analyze what they hear in a piece of periodic music. My goal is to provide analytical guidelines within which differing interpretations can exist.

Demonstrations of the Similarities

The similarities between Reich and Ligeti's music constitute a common practice—the superposition of periodic structures. The elements of this common practice will play a central role in shaping the definitions, categories, and hierarchical relationships described within my method. I will demonstrate this common practice by focusing on compositional techniques and common influences of the two composers.

My discussion of Reich will center on the development of his compositional techniques that result in the superposition of periodic structures. I have chosen musical

examples that reflect innovations in this development. I will focus specifically on pieces where canons are created through phasing and rhythmic construction.

There are three groups of György Ligeti's compositions that are relevant to this study: the *meccanico* works, the works influenced by the American minimalist school, and pieces that utilize principles of African rhythm. I will discuss keyboard works from these groups that reflect similarities to Reich's music.

Steve Reich

Reich's first phase pieces were *It's Gonna Rain* (1965) and *Come Out* (1966). They are seminal tape pieces to which almost all of Reich's compositional paths can be traced. They consist entirely of recorded human speech patterns that yield a variety of unexpected interactions when they are subjected to the phasing process. Phasing also results in a musical continuity that was very important for Reich:

I discovered that the most interesting music of all was made by simply lining the loops up in unison, and letting them slowly shift out of phase with each other. As I listened to this gradual phase shifting process, I began to realize that it was an extraordinary form of musical structure. This process struck me as a way of going through a number of relationships between two identities without ever having any transitions. It was a seamless, continuous, uninterrupted musical process.⁶

Even the casual listener can easily perceive the process of phasing; however, its underlying musical meaning is profound. Phasing allows the coexistence of change and continuity within a single moment in a musical work. Reich's early phase pieces illustrate the continuity that results from letting instrumental lines gradually shift out of phase. Although other techniques of displacement are conceivable (stopping and starting

⁶ K. Robert Schwarz, "Steve Reich: Music as a Gradual Process," *Perspectives of New Music* 19 (1980-1981): 384.

patterns; dropping and repeating pitches), they do not achieve the same level of continuity.⁷ Instead, the gradual application of phasing creates a co-mingling of what has come before and what lies ahead.

Phasing grew out of Reich's experience with electronic media, but he then successfully applied it to acoustic instruments beginning with *Piano Phase* and *Violin Phase*. Reich viewed his early tape pieces as "realizations of an idea that was indigenous to machines, and on the other hand, the gateway to some instrumental music I would never have come to by listening to any other Western, or for that matter, non-Western music."⁸

Figure 1: *Piano Phase*, mm. 1-6

The musical score for *Piano Phase*, measures 1-6, is presented in two systems. Each system contains two staves: the right hand (r.h.) on top and the left hand (l.h.) on the bottom. The music is in 4/4 time and features a single melodic line that is gradually phased between the two hands.
 System 1 (Measures 1-3):
 - Measure 1: Right hand (r.h.) begins with a melody marked *mf* non legato. Left hand (l.h.) is silent.
 - Measure 2: Right hand continues. Left hand enters with the same melody, marked *mf* non legato.
 - Measure 3: Both hands continue. The left hand's melody is slightly ahead of the right hand's.
 System 2 (Measures 4-6):
 - Measure 4: The right hand's melody is now slightly ahead of the left hand's.
 - Measure 5: The left hand's melody is now ahead of the right hand's.
 - Measure 6: The right hand's melody is ahead of the left hand's.
 The score includes various performance instructions: *mf*, *non legato*, *fade in*, *hold tempo 1*, *accel. very slightly*, and *a.v.s.* (ad libitum). Repetition counts are indicated above the staves: (x4-8), (x12-18), (x4-16), (x16-24), and (x4-16).

⁷ Reich's last phase piece, *Clapping Music* (1972), does not possess the same "seamless continuity" as his earlier phase pieces. After twelve repetitions of each measure, the next phase relationship occurs immediately instead of gradually as before. Although the results of immediate phasing are interesting, the continuity present in the earlier phase pieces is less pronounced.

⁸ Schwarz, "Steve Reich: Music as a Gradual Process," 387.

Piano Phase is written for two live performers on two pianos. In measure 1, The first player begins by playing a pattern of twelve sixteenth notes. The second performer slowly fades in with the same pattern in measure 2 until both players are playing in unison at the same volume. After playing the approximate number of repetitions Reich indicates, the two pianists assume different roles. The first pianist (subsequently referred to as Player 1) continues as before, while the second pianist (Player 2) accelerates very slightly until he has eased his pattern ahead of Player 1 by one sixteenth note. Each measure contains a new canon; the phasing process acts as an uninterrupted agent of change from one measure to the next. This process of acceleration and displacement continues for all twelve pitches until the pianists are playing in unison once more in measure 14. *Piano Phase* ends after Reich introduces two more patterns of eight and four notes respectively and subjects them to the same procedures.

Figure 2: *Violin Phase*, mm. 9 and 9a

The musical score for *Violin Phase*, measures 9 and 9a, is presented in four staves. The first two staves, labeled 'TAPE TRK 2 (VIOLIN 1)' and 'TAPE TRK 2 (VIOLIN 3)', show the individual parts for two violins. The third staff, labeled 'Result of TAPE TRACK 2 (VIOLINS 1+3)', shows the combined sound of these two parts. The fourth staff, labeled 'VIOLIN (VIOLIN 2)', shows a single violin part. The score includes a 'Fade in' line and a 'f' (forte) dynamic marking. The measures are marked with circled '9' and '9a'.

Violin Phase is written for violin and tape or four violins. Reich applies the same phasing process as before, but instead of leaving the resulting patterns up to the listener's interpretation, he notates some of them. It is the first composition in which Reich notates

resulting patterns. In a survey of Reich's compositional development, Robert K. Schwarz eloquently states the significance of the notated patterns: "The live violinist's process of 'pointing out' the resulting patterns guides the listener's perception and opens up the listener's ears to melodic combinations he or she may not have heard: the effect is almost that of bringing a transitory aural illusion into the realm of reality."⁹

Reich noticed these same kinds of "aural illusions" in the form of polyrhythms in African music.¹⁰ In fact, his trip to Ghana in 1970 to study African drumming confirmed the path he had started down five years earlier—his discovery and application of the phasing technique.¹¹

He also noticed that the musical structures in African music were predetermined, which left little room for improvisation.¹² This mirrored his compositional practice in two ways. First, it is similar to Reich's techniques in that "once the process is set up and loaded it runs by itself."¹³ Second, since the process is worked out beforehand, the group performance supercedes that of the individual's. Regarding these performer roles in African music, Schwarz states that

All members of the African percussion ensemble must subject their personal expression to the higher goal of a precise rendition of repetitive, interlocking rhythmic patterns within the framework of a live group performance. In addition, the patterns themselves, modally based and relying on steady pulse to give them life, served to endorse Reich's perceptions of his own music.¹⁴

⁹ Ibid., 387.

¹⁰ K. Robert Schwarz, "Steve Reich: Music as a Gradual Process, Part II," *Perspectives of New Music* 20 (1981-1982): 230.

¹¹ Steve Reich, "Non Western Music and the Western Composer," *Analyse Musicale* 11 (April 1988): 48.

¹² Schwarz, "Steve Reich: Music as a Gradual Process, Part II," 233.

¹³ Reich, "Music as a Gradual Process," 9.

¹⁴ Schwarz, "Steve Reich: Music as a Gradual Process, Part II," 233.

Reich wrote *Drumming* after his trip to Africa and is the first piece in which he used rhythmic construction. In Part One, the drum pattern gradually enters one note at a time and is then completed by the replacement of notes with rests.

Figure 3: *Drumming*, Rhythmic construction in mm. 1-8



Reich combines the techniques of rhythmic construction and phasing in *Six Pianos* by using them to produce a series of canons. Beginning in m. 2, Reich gradually constructs a canon using the pattern in Player 3. When the process is completed in m. 9, the result is a fully constructed pattern in Players 4 and 5 that is two beats (eighth-notes) behind the same pattern in Player 3 (indicated by asterisks).

Figure 4: *Six Pianos*, Rhythmic Construction in mm. 2-9



Figure 4 (continued)



Although rhythmic construction can achieve the same result as phasing, there are some important differences between the two techniques. In phasing, the rhythmic interval between the displaced parts is variable; it changes incrementally throughout the piece. Rhythmic construction creates a canon with a fixed rhythmic interval; the degree of rhythmic displacement is predetermined.

Both processes consist of two stages: the gradual creation of a canon and the completed result. I chose to analyze *Six Pianos* in Chapter 4 because the process of rhythmic construction contains quantifiable resulting patterns in both of its stages. Phasing presents more of a challenge in this regard because the resulting patterns during canon creation are in a constant state of flux. Although these patterns are clearly audible, they are likely to change from one performance to another. Only the second stage of phasing contains resulting patterns that are in the notation. In contrast, resulting patterns exist in the notation during both stages of rhythmic construction. *Six Pianos* contains a wide variety of these patterns; this makes it a favorable test case for an analytical method that deals with interactions between periodic structures.

György Ligeti

Interactions between periodic structures also play a prominent role in György Ligeti's music. I will focus on three groups of Ligeti's keyboard compositions that contain these structures: the *meccanico* compositions, works influenced by the American minimalist school, and works that reflect that influence of African music.

Richard Toop describes Ligeti's *meccanico* works as "protominimalist" since they exhibit characteristics of the American minimalist school despite being written during a time when Ligeti was unaware of the minimalists' work.¹⁵ Jane Piper Clendinning describes the typical features of Ligeti's *meccanico* style:

In each of the compositions of the [*meccanico*] group, the [*meccanico*] sections are composed of several overlaid linear strands, each of which is constructed from small groups of pitches rapidly repeated in a mechanical fashion with gradual changes of pitch content.¹⁶

Figure 5: *Continuum*, mm. 1-12



¹⁵ Richard Toop, *György Ligeti*, (London: Phaidon, 1999), 125.

¹⁶ Jane Piper Clendinning, "The Pattern-Meccanico Compositions of György Ligeti," *Perspectives of New Music* 31/1 (1993): 194-5.

Continuum (1969) for harpsichord consists entirely of *meccanico* activity. Even though Ligeti was not aware of the works of the American minimalist school at the time he composed *Continuum*, its repetitive qualities and diatonic patterns have much in common with Reich's music.¹⁷ And much like Reich's music, Ligeti's music of this time consists of different rhythmic layers superposed upon one another. Regarding these layers, Ligeti states: "...what attracts me is the idea of superimposing several levels, several different time-grids moving at different speeds, and so very subtly achieving rhythmic deviations."¹⁸ Ligeti describes *Continuum* as a "pattern-illusion piece à la Maurits Escher" because of the patterns and sensations of changing rhythms that arise from overlapping pitch cycles played at a fixed tempo.¹⁹ Regarding the illusory rhythms that arise from the *meccanico* technique in *Continuum*, Ligeti states:

Here what you perceive as rhythm is not rhythm coming from the succession of notes your fingers play. The actual rhythm of the piece is a pulsation that emerges from the distribution of the notes, from the frequency of their repetitions...the *accelerando* of the rhythm is therefore the result of an increased frequency of a note, it is realized through a modified note distribution.²⁰

The note distributions of which Ligeti speaks are made possible by the interactions of pitch cycles in each hand. Much like Reich's resulting patterns in *Piano Phase*, *Continuum*'s illusory patterns result from changing note relationships amidst fixed rhythmic durations. In Figure 6 I have illustrated the lengths and large-scale interactions

¹⁷ Toop, 124.

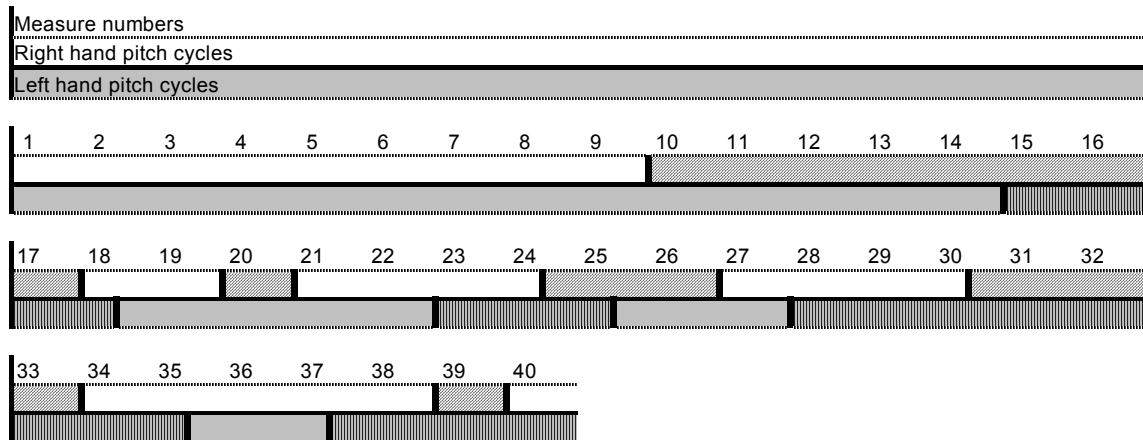
¹⁸ György Ligeti, interview by Josef Häusler, *György Ligeti in Conversation*, trans. Sarah E. Soulsby (London: Eulenberg Books: 1983), 108.

¹⁹ György Ligeti, Introduction to the brochure notes for *György Ligeti Keyboard Works* Vol. 6, Irina Kataeva and Pierre-Laurent Aimard, SK 62307, 17.

²⁰ György Ligeti, interview by Péter Várnai, *György Ligeti in Conversation*, trans. Gabor J. Schabert (London: Eulenberg Books: 1983), 61.

of these pitch cycles using shaded bars. The alternating patterns on the bars are merely for visual contrast; they do not have any musical significance.

Figure 6: *Continuum*, pitch cycles in mm. 1-40



Interaction between the two pitch cycles creates the impression of changing rhythms even though notated rhythmic cycles are absent.

Ligeti continues creating interactions from superposed periodic structures in *Three Pieces for Two Pianos* (1976). I will focus on the first and second movements because they contain different types of periodic interactions. “Monument” contains cyclic activity in an inverse relationship to the cycles in *Continuum*. In *Continuum*, overlapping pitch cycles are set within fixed durations. “Monument” consists of overlapping rhythmic cycles that each consist of a single pitch class. The second movement, “Selbstportrait mit Reich und Riley (und Chopin ist auch dabei),”²¹ exhibits a direct influence from the American minimalist school. It features a section with phasing processes similar to those in Reich’s music. “Monument” does not have a stated reference to Reich’s practice, but

²¹ Commonly translated as “Self-Portrait with Reich and Riley (with Chopin in the background).”

its periodic structures and the process of their execution are explicit musical references nonetheless.

In the musical excerpt from “Monument” in Figure 7, I use brackets to indicate the delineations of rhythmic cycles. I will refer to four cycles:

- 1) Cycle A: Piano I; occurs on pitch class A; first occurrence in m. 6
- 2) Cycle B: Piano I; occurs on pitch class B; first occurrence in m. 19
- 3) Cycle C: Piano II; occurs on pitch class G^b; first occurrence in m. 13
- 4) Cycle D: Piano II; occurs on pitch class C; first occurrence in m. 23

Figure 7: “Monument,” mm. 6-25

The image displays a musical score for two systems of staves, labeled I and II. The first system covers measures 6 through 10, and the second system covers measures 11 through 15. Handwritten annotations include brackets and labels [A], [C], and [A] indicating specific rhythmic cycles. The notation includes various musical symbols such as notes, rests, and dynamic markings.

Figure 7 (continued)

The image displays two systems of musical notation, each consisting of two staves labeled I and II. The first system covers measures 16 through 20. In measure 16, staff I has a bracket labeled [B] and staff II has a bracket labeled [C]. In measure 19, staff I has a bracket labeled [B] and staff II has a bracket labeled [C]. In measure 20, staff I has a bracket labeled [B] and staff II has a bracket labeled [C]. The second system covers measures 21 through 25. In measure 21, staff I has a bracket labeled [A] and staff II has a bracket labeled [D]. In measure 22, staff I has a bracket labeled [A] and staff II has a bracket labeled [D]. In measure 23, staff I has a bracket labeled [A] and staff II has a bracket labeled [D]. In measure 24, staff I has a bracket labeled [A] and staff II has a bracket labeled [D]. In measure 25, staff I has a bracket labeled [A] and staff II has a bracket labeled [D].

I use different bracket sizes to distinguish between the first (A and C marked by larger brackets) and subsequent cycles (B and D marked by smaller brackets) in each hand.

I continue to use brackets and labels as the cycles repeat.

The first overlap occurs between cycles A and C in m. 13. Three cycles overlap in m. 19 with addition of cycle B. The introduction of cycle D in m. 23 results in a four layer interaction. The rhythmic aspect that remains fixed is not the durations; otherwise, Ligeti could not continue inserting new cycles among the continuing ones. Instead, it is the durations between attacks that remain fixed. The smallest durational change in the cycles is a sixteenth note; therefore, I will describe the attacks and durations according to their length in sixteenth notes. In Figure 8 I have abstracted the patterns from the music to demonstrate the durations between attacks. Every attack is one sixteenth note long, and

the numbers above the staves represent the number of sixteenth note durations between attacks.

Figure 8: “Monument,” rhythm cycles A, B, C, and D

Cycle A



Cycle B



Cycle C



Cycle D



I have detailed the properties of the four cycles above to demonstrate Ligeti’s rigorous cyclic usage. These rhythmic cycles are similar not only in their execution but in their structure. In each cycle, rests are added and subtracted between the notes in identical amounts. The results of the cyclic consistency in “Monument” are demonstrative of Reich’s early compositional philosophy: “...once the process is set up and loaded it runs by itself.”²²

“Selbsportrait” also bears similarities to Reich’s practice, but in a different form. Paul Griffiths quotes Ligeti describing the piece as having “a touch of irony (and no less self-irony, as I also depicted myself), combining the techniques of Riley’s pattern repetition and Reich’s phase shifting with my own techniques of superimposed grids and

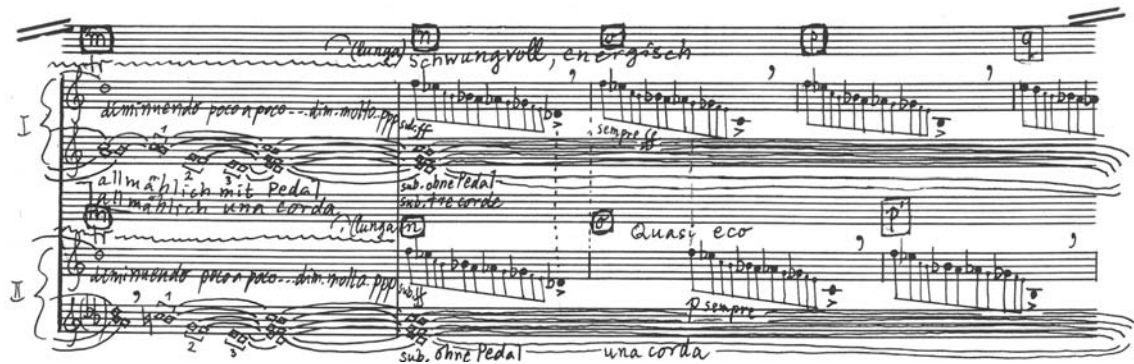
²² Reich, “Music as a Gradual Process,” 9.

supersaturated canons. Thus originated the triple portrait Riley-Reich-Ligeti.”²³ Ligeti was delighted when he first heard the music of Terry Riley and Steve Reich:

We had come up with similar ideas independently of each other, at the same time, and in geographically distant places—I with my metronome piece and *Continuum*, Riley with *In C*, and Reich with *It’s Gonna Rain* and *Violin Phase*. And so I wanted my piano piece to be an homage to the musical kinship with these two Americans....²⁴

The second section of this movement (from rehearsal letter n to rr) with its phasing patterns is the homage to Reich. Rehearsal letter n (Figure 9) begins with Pianos I and II playing an identical descending pitch pattern. As the piece progresses, the pianos continue to play the same pattern in varying degrees of displacement. The final pitch of each pattern is accented to highlight the displacement, and in the process a composite melody emerges. At letter MM (Figure 10) a more rapid phasing process takes place. Piano I enters first, followed by Piano II at MM'.

Figure 9: “Selbsportrait,” Rehearsal n-v



²³ Paul Griffiths, *György Ligeti* (London: Robson Books, 1983), 95.

²⁴ Ligeti, Introduction to the brochure notes for *György Ligeti Keyboard Works*, vol. 6, 18.

Figure 9 (continued)

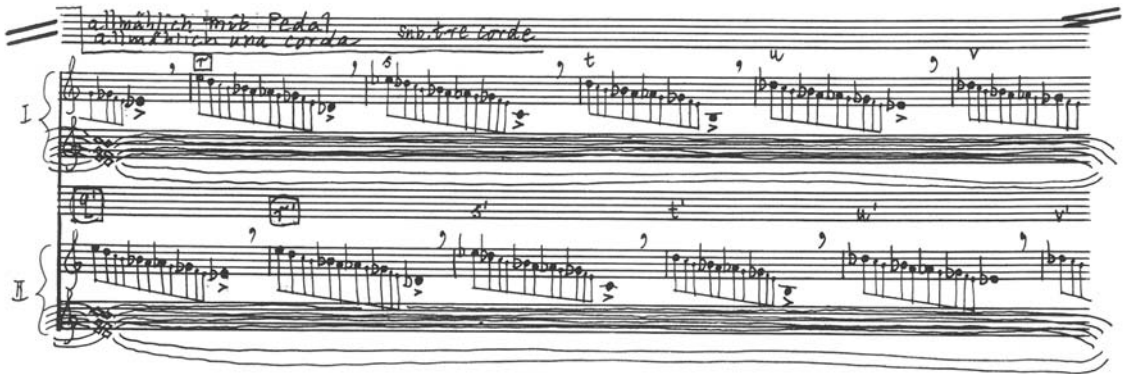


Figure 10: “Selbsportrait,” Rehearsal MM

Ligeti refers to *Three Pieces for Two Pianos* as the “development of the pattern-illusion experiments of *Continuum* and, simultaneously, the first step towards my piano études.”²⁵ Like *Continuum*, “Monument” and “Selbsportrait” exhibit superposed

²⁵ Ibid., 17-18.

structures; the cycles in “Monument” are rigorously periodic, while the shifting canons in “Selbsportrait” are an emulation of Reich’s phasing technique.

I have demonstrated the many technical similarities between Reich and Ligeti; perhaps some of these similarities are related to their common interest in African rhythms. Ligeti first encountered African music through the recordings of the Israeli musicologist Simha Arom. Regarding the influence of African music on his etudes, Ligeti states:

A rich source of such acoustic/motor pleasures is to be found in the music of many sub-Saharan African cultures. The polyphonic ensemble playing of several musicians on the xylophone—in Uganda, the Central African Republic, Malawi and other places—as well as the playing of a single performer on a lamellophone (mbira, likembe, or sanza) in Zimbabwe, the Cameroon, and many other regions, led me to search for similar technical possibilities on the piano keys....Two insights were important to me: one was the way of thinking in terms of patterns of motion (independent of metric notions); the other was the possibility of gleaning illusory melodic/rhythmic configurations—heard, but not played—from the combination of two or more real voices (analogous to Maurits Escher’s “impossible” perspectives).²⁶

The reference to Escher is reminiscent of Ligeti’s earlier quote regarding *Continuum*. The fact that Ligeti references Escher in relationship to works written both before and after his exposure to African music implies that the principles of African music were not entirely new to him. I believe Ligeti was drawn to African music for the same reason as Reich; the principles of African rhythm served as a confirmation of his established compositional techniques.

As I stated earlier in this chapter, *Désordre* was the first of Ligeti’s piano etudes with which I became familiar. In *Désordre*, Ligeti continues his compositional practice

²⁶ György Ligeti, Introduction to the brochure notes for *György Ligeti Keyboard Works*, vol. 3, Pierre-Laurent Aimard, SK 62308, 9-10.

found in *Continuum* and *Three Pieces for Two Pianos*; it contains superposed periodic structures made up of repeated pitch and rhythm cycles. Ligeti uses techniques similar to Reich's to create these structures: shifting pitch cycles of fixed rhythmic durations, rigorous and consistent application of compositional processes, and the creation of canons. In my opinion, these similarities make *Désordre* an appropriate companion to *Six Pianos* as a subject for my analysis in Chapter 4.

The Contributions of Other Authors

The writings of several authors have been very helpful to me as I have developed my thinking about the issues of Reich, Ligeti, and periodic rhythmic structures. K. Robert Schwarz's excellent pair of articles, "Music as a Gradual Process I and II," as well as his text, *Minimalists*, guided me through the chronology of Reich's compositional development. Schwarz's writings were also the first time I had encountered an attempt in the scholarly literature to make analytical observations about Reich's music.²⁷ His descriptions of Reich's techniques helped me to clarify precisely what I heard in Reich's music. Schwarz's serious treatment of Reich's career and works is the foundation for this study.

The work of Jane Piper Clendinning and Richard Toop concerning Ligeti is analogous to Schwarz's significance for Reich. In her article, "The Pattern-Meccanico Compositions of György Ligeti,"²⁸ I encountered a very precise and lucid description of Ligeti's compositions. Her pattern-interaction graphs for *Continuum* provided clear

²⁷ K. Robert Schwarz, "Steve Reich: Music as a Gradual Process," *Perspectives of New Music* 19 (1980-1981): 373-392; "Steve Reich: Music as a Gradual Process, Part II," *Perspectives of New Music* 20 (1981-1982): 225-286; *Minimalists* (London: Phaidon, 1996).

²⁸ Jane Piper Clendinning, "The Pattern-Meccanico Compositions of György Ligeti," *Perspectives of New Music*, Vol. 31, No.1 (Winter 1993): 192-234.

representation of musical phenomena; their impact on my own figures in later chapters is obvious. With these graphs, Clendinning provided me with a sense of perspective, something for which I am always striving in my efforts to comprehend musical structure. Because of her graphs I was able to comprehend the pattern interactions in *Continuum* at a glance. I have chosen elements from her graphs to use in my figures in the hopes that the same clarity will be present.

Like Schwarz, Toop provides an excellent chronological and technical survey of Ligeti's music in *György Ligeti*.²⁹ I found his text particularly helpful in regards to Ligeti's etudes; much of the literature about Ligeti was not recent enough to account for these compositions. He provides an excellent account of the influences that are present in the etudes as well a good discussion of their musical characteristics.

In terms of rhythmic analysis, Maury Yeston's ideas in *The Stratification of Musical Rhythm* were groundbreaking for me.³⁰ I had never considered the idea of rhythmic strata, but I found that this concept was a perfect description of the phenomena I perceived in Reich and Ligeti's music. Also, the hierarchies and generative relationships between different rhythmic strata were ideas I had never encountered before. His ideas helped me to understand what I was hearing in Reich and Ligeti's music and how to explain it. The hierarchical elements of my analytical method (see Chapter 3) have their roots in Yeston's ideas. I did not incorporate the more specific aspects of his study into this one; rather, it was the ideas of rhythmic strata and their interactions in general that helped me to understand the principles behind Reich's and Ligeti's music. Jonathan

²⁹ Richard Toop, *György Ligeti* (London: Phaidon, 1999).

³⁰ Maury Yeston, *The Stratification of Musical Rhythm* (New Haven: Yale University, 1976).

Kramer's "hyper-measure" concept directed my thinking in a similar way regarding different levels of rhythmic structure.³¹

When I discovered that Arom was the channel of the African influence for Ligeti, I sought out his writings and found *African Polyphony and Polyrhythm*.³² In it I found many similarities to Yeston's ideas: namely, the nature of interactions between different rhythmic levels. Arom's descriptions of rhythmic phenomena in African music applied to Reich and Ligeti's music exactly. His diagrams of composite rhythms between two or more separate lines contributed directly to my thinking regarding what I later refer to as "composites" in the exposition of my method in Chapter 3. The specificity of Arom's classifications of polyrhythmic elements led me to use some of his definitions to account for interactions between periodic structures. Like Yeston, his role in the development of my thought concerning rhythmic levels is indispensable.

The writings of Arom and Yeston were not the only ones influential to my thinking about rhythm. At the direction of Howard Meltzer I went to Olivier Messiaen's *Technique de mon langage musical*.³³ The writings of Messiaen presented to me a profound set of ideas about rhythm. In particular, I was interested in Messiaen's discussion of rhythm in relationship to notation. The relevance of notation, specifically barlines, is immediately questionable in music like Reich and Ligeti's that is based on periodic structures. Messiaen's music is the ideal example of how to deal with this conflict, since his music also treats barlines only as an aid to the performer. This idea,

³¹ Jonathan Kramer, *The Time of Music* (London: Schirmer, 1988), 83.

³² Simha Arom, *African Polyphony and Polyrhythm*, trans. Martin Thom, Barbara Tuckett and Raymond Boyd (Cambridge: Cambridge University Press, 1991).

³³ Olivier Messiaen, *Technique de mon langage musical*, vol. 1, trans. John Satterfield (Paris: A.Leduc, 1956).

coupled with the presence of periodic structures in his music, led me to devote a chapter to his and Arom's ideas as precedents for this study. Since the strict use of periodic structures is a process, I saw yet another link between Messiaen's musical practice and that of Reich and Ligeti. The writings of both men deal with the consequences of periodicity, whether they are notational or aural.

The most rigorous analytical treatment of Reich's music I have seen is by Richard Cohn.³⁴ He applies aspects of pitch class (pc) set theory to the rhythmic structures of Reich's early phase pieces. This allows him to identify specific characteristics of individual patterns, their combinations, and their relationships to one another. The application of pc set terminology to this repertoire is useful; in Chapter 4 I will use ordered pc set terminology to describe relationship between rhythmic structures. While I do not apply Cohn's method per se, I found it useful as I developed my analytical method.

I will implement my method in Chapter 4; Chapters 2 and 3 will lay the groundwork for this later analysis. In Chapter 2 I will discuss the music and writings of Olivier Messiaen as a precursor for the techniques in the music of Reich and Ligeti. I will also reference the writings of the Israeli musicologist Simha Arom; he has written extensively on the topics of rhythmic periods and their interaction in African music.

Arom introduces many concepts that are directly applicable to periodic music outside the African tradition. In Chapter 3 I will adapt some of his ideas to my method for

³⁴ Richard Cohn, "Transpositional Combination of Beat-Class Sets in Steve Reich's Phase-Shifting Music," *Perspectives of New Music* 31/1 (1993): 192-234.

analyzing music based on periodic rhythmic structures. I will explain the terminology and the approach involved in using my method.

After applying my method to the music of Reich and Ligeti in Chapter 4, I will conclude this study in Chapter 5 and offer ideas for its further application.

CHAPTER 2

PULSE, PROCESS, AND PERIODICITY: CONCEPTUAL PRECUSORS TO THE MUSIC OF STEVE REICH AND GYÖRGY LIGETI

The music of Olivier Messiaen and the writings of Simha Arom both deal with the concept of periodicity. Messiaen stands out among composers of the first half of the twentieth century in his strict use of pitch and rhythmic periods. Arom's writings document periodicity in African music, but he also discusses the effects of period combinations using descriptions and definitions for various rhythmic phenomena.

Although there is not a direct link between these two men, their ideas are useful to this study for several reasons. First, Arom's writings are relevant not only to African music but to Western periodic music as well. His discussion of African rhythmic practice provides useful ways of describing the phenomenon of periodicity in music composed later in the twentieth century—namely, that of Reich and Ligeti. His ideas can be easily incorporated into an analytical method that provides meaningful information about Western periodic music. Second, Messiaen's music provides a starting point for a discussion of periodic music composed in the twentieth century. Like Arom's writings, Messiaen's music exhibits characteristics that are present in all periodic music in varying degrees. Like much of Reich's music, some of Messiaen's music is process-based. I will begin my discussion of Messiaen by turning to his writings about rhythm and notation.

Olivier Messiaen

Messiaen drew a distinction between what the composer notates for the convenience of the performer and the composer's original conception. In "Rhythmic Notations," Chapter Seven of *Technique de mon langage musical*, he speaks of this distinction under the heading "Fourth Notation":

It consists, by means of syncopes, of *writing in a normal meter a rhythm which has no relation to it*. This procedure is indispensable when it is a question of having performed by several musicians a superposition of several rhythms, complicated and very different from each other. In order to produce the effect, it suffices to multiply the indications of slurs, dynamics, and especially accents exactly where one wants them. *This notation is false, since it is in contradiction to the rhythmic conception of the composer; but if the performers observe the indicated accents well, the listener hears the true rhythm* (emphasis mine).¹

According to Messiaen, the notation does not represent the "rhythmic conception of the composer"; hence, it is "false." However, the falsity of the notation is necessary to coordinate the efforts of musicians executing different rhythms simultaneously. The composer's goal is that the listener perceive the "true rhythm," even if the notation has to be adjusted to ensure proper performance.

Figure 11: Examples of the Fourth Rhythmic Notation

Figure 11 displays three musical staves illustrating the Fourth Rhythmic Notation, which uses syncopes to represent a rhythm that contradicts the written meter.

Staff 67: Trompette, *Les Offrandes oubliées*, *ff*. The notation shows a complex rhythmic pattern with multiple accents and slurs, indicating a true rhythm that differs from the written meter.

Staff 68: Clarinette en Sib, *Liturgie de cristal*, *p expressif*. The notation shows a complex rhythmic pattern with multiple accents and slurs, indicating a true rhythm that differs from the written meter.

Staff 69: Clarinette en Sib, *Liturgie de cristal*, *p expressif*. The notation shows a complex rhythmic pattern with multiple accents and slurs, indicating a true rhythm that differs from the written meter.

¹ Olivier Messiaen, *Technique de mon langage musical*, vol. 1, trans. John Satterfield (Paris: A.Leduc, 1956), 29.

Employing “false notation” to achieve the “true rhythm” raises the question, “What does false notation look like?” According to the quote above, false notation involves “writing in a normal meter a rhythm which has no relation to it.” This rhythm is achieved by the “indications of slurs, dynamics, and especially accents where one wants them.” If rhythms that do not follow the normal accentual patterns of 4/4 time are notated in that time signature, the traditional metric interpretation must be discarded in favor of the composer’s instructions. However, the retention of the barline is often necessary to aid the performer. Concerning Messiaen’s use of the barline, Pierre Boulez states:

Not only does he frequently use rhythms that may be considered irregular, but if he uses more-or-less regular bar lines it is often only to make things easier for the performer... The idea of regular metre gradually disappears from his music....²

With the disappearance of regular meter in Messiaen’s music, the pulse becomes the fundamental unit of rhythmic organization.

The rhythmic pulse and false notation are inseparable ideas that determine how to execute music like Messiaen’s. When interpreted in a traditional manner, the time signature and barlines prohibit the expression of Messiaen’s musical ideas. All that remains is the rhythmic pulse, the most fundamental unit of metric organization that is relevant to any musical context.

Boulez also notes the eternal quality of Messiaen’s later music:

Messiaen takes, for instance, an initial idea with a certain number of interversions and chosen permutational principles, and once these interversions have run their course the piece can be considered as finished. Almost all the pieces in the *Livre d’orgue* ‘run out’ in this way, and it is precisely for this reason that they end with such surprising abruptness....

² Pierre Boulez, *Orientations*, ed. Jean-Jacques Nattiez, trans. Martin Cooper (Cambridge: Harvard University, 1986), 409.

But whether he uses these markings or not, it is clear that these ‘pieces’ do not have an end, in the rhetorical sense; they simply *stop*. Their strict organization means that they are like fragments of some larger whole that is tacitly understood. The actual beginning and end of a piece do not constitute its real limits, with a ‘before’ and an ‘after’.³

Figure 12: “Reprises par Interversion,” mm. 1-14

The musical score for "Reprises par Interversion" (mm. 1-14) is presented in three systems. The first system (mm. 1-5) begins with a tempo marking of "Modéré" and a key signature of one sharp (F#). The MAN. part (Mandolin) starts with a melody in G major, marked "non legato" and "m.f.". The PÉD. part (Pedal) provides a bass line, marked "ff" and "non legato". The second system (mm. 6-9) continues the melody and bass line. The third system (mm. 10-14) concludes the piece with a final "ff" marking. The score includes various musical notations such as notes, rests, and dynamic markings.

One piece from *Livre d'orgue* that fits Boulez's description is "Reprise par Interversion" ("Repetitions through Reversal"). The plan for the piece is straightforward, and once the process has run its course, the piece stops. "Reprise par Interversion"

³ Ibid., 414-5.

consists of four sections, the last three being generated from the material in the first section. The first section consists of three alternating Hindu rhythms, known as *pratâpaçekhara* (P), *gajahampa* (G), and *sârasa* (S). Measures are not defined in the traditional sense; they are determined by the length of the patterns they contain. The 18 measures of Section 1 consist of six different orderings of the three rhythms:

Measures 1, 2, 3: PGS

Measures 4, 5, 6: PSG

Measures 7, 8, 9: GSP

Measures 10, 11, 12: GPS

Measures 13, 14, 15: SGP

Measures 16, 17, 18: SPG

Messiaen then manipulates this material to generate Sections 2, 3, and 4. Because mm. 1-9 and 10-18 are used as groups to generate the rest of the piece, I will label them as A and B respectively. Section 2 is created by playing the beginning and the end of Section 1 simultaneously, which means that A is played at the same time with the retrograde of B, making this section half the length of Section One. Section 3 consists of the simultaneous performance of B and the retrograde of A. Section 4 is a palindrome of Section 1, which results in the complete retrograde of Section 1. Figure 12 demonstrates the process by which the piece is generated. The left column contains the section numberings, the rows indicate measure numbers and Hindu rhythmic patterns, and the subscript “r” indicates a retrograded section. The missing measures in the diagram (19, 9, 39) are measures of rests between sections.

Figure 13: Diagram of “Reprise par Intversion”

1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	A									B								
	P	G	S	P	S	G	G	S	P	G	P	S	S	G	P	S	P	G
2	20	21	22	23	24	25	26	27	28									
	A																	
	P	G	S	P	S	G	G	S	P									
	B _r																	
G	P	S	P	G	S	S	P	G										
3	30	31	32	33	34	35	36	37	38									
	B																	
	G	P	S	S	G	P	S	P	G									
	A _r																	
	P	S	G	G	S	P	S	G	P									
4	B _r									A _r								
	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
	G	P	S	P	G	S	S	P	G	P	S	G	G	S	P	S	G	P

The cumulative effect of the repetitions and retrogrades of A and B in mm. 30-57 is the retrograde of mm. 1-28.

As I stated in the introduction to this chapter, another aspect of Messiaen’s compositions that can be found in the music of Reich and Ligeti is periodicity. “Liturgie de cristal,” the first movement of *Quartet for the End of Time*, exhibits periodicity on several levels. The cello and piano parts both consist of simultaneous rhythmic and pitch series that repeat throughout the course of the movement. Although these series are simultaneous, their beginnings and endings are not congruent with one another. In the cello part, the pitch series consists of five notes and the rhythmic series consists of fifteen values. The pitch series is repeated twenty-two times and the rhythmic series completes seven repetitions. These same principles are used in the piano part; a rhythmic series of seventeen values overlaps with a series of twenty-nine chords.

Figure 14: “Liturgie de Cristal,” mm. 1-6

The musical score for "Liturgie de Cristal" (measures 1-6) features three staves: Violoncelle, Piano, and Voix (labeled "Velle"). The Violoncelle part is marked *ppp (vibrato)*. The Piano part is marked *pp legato (très enveloppé de pédale)* and includes a tempo/mood instruction: **A Bien modéré, en poudrolement harmonieux (♩=54 environ)**. The Voix part is marked *glissando* and includes a note marked with an asterisk (*).

Messiaen's musical ideas transcend traditional metric boundaries; the notation does not often reflect their true nature. He also subjects musical materials to strict processes; these materials are sometimes periodic in nature. His use of notation and periodic structures is a precursor of similar structures in the music of Reich and Ligeti. The music of these three composers often exhibits a quality of suspended time that is quite different from the goal-oriented notions of time in Western art music. Their music seems to have more in common with non-Western musical practice. Principles of African rhythmic practice play an important role in the music of Reich and Ligeti, and I will now use Simha Arom's work in this area to highlight this role.

Simha Arom

African rhythms are structured periodically. Reich's and Ligeti's music contains structural evidence of an African influence, and in their writings they have referred to the work of Simha Arom as one of the channels of this influence.

In the foreword to Arom's *African Polyphony and Polyrhythm*, Ligeti describes his first impressions of African music after listening to Arom's recordings in 1982:

"Having never before heard anything quite like it, I listened to it repeatedly and was then, as I still am, deeply impressed by this marvellous polyphonic, polyrhythmic music with its astonishing complexity." Two years later, Ligeti had the opportunity to meet with Arom in Jerusalem. During this meeting Arom showed Ligeti transcriptions of African music in full score and explained their melodic and rhythmic structure.⁴

Reich became aware of Arom's work in 1975. While in Paris in 1976, he met briefly with Arom and became "superficially aware of his work with multi-track recording and transcription in Central Africa."⁵ In 1987 Reich received a copy of Arom's "*magnum opus*," *African Polyphony and Polyrhythm*. Although his knowledge of French was limited, he "could see from the musical examples that this was obviously a contribution to ethnomusicology of the highest order."⁶ Reich received the copy of Arom's book while working on *Electric Counterpoint* and incorporated a pattern for three horns transcribed therein. This was the first time Reich incorporated an African theme in

⁴ Ligeti, Foreword to *African Polyphony*, xvii., György Ligeti, foreword to *African Polyphony and Polyrhythm*, by Simha Arom, trans. Martin Thom, Barbara Tuckett and Raymond Boyd (Cambridge: Cambridge University Press, 1991), xvii.

⁵ Reich, "Non-Western Music and the Western Composer," 48.

⁶ Ibid.

his music, although he had been composing music based on principles of African rhythm as early as 1970 (e.g., *Drumming*).⁷

Periodicity in *African Polyphony and Polyrhythm*

Arom discusses periodicity extensively in *African Polyphony and Polyrhythm*. He includes it in a list of five fundamental characteristics of Central African percussion ensemble rhythms:

- 1) Stable movement, free of *accelerando*, *rallentando*, or *rubato*
- 2) Strict periodicity, which results from uninterrupted rhythmic patterns occurring in regular intervals of time
- 3) Variability within the repetitive context
- 4) Interwoven rhythms resulting from instrumental parts that are not in exact vertical alignment
- 5) A lack of strong and weak beats due to the absence of a predetermined metric framework based on the alternation of accented and unaccented sounds⁸

Arom observes a quality of African rhythmic practice that is common to the periodic music of Reich, Ligeti, and Messiaen:

The interweaving of accents and tone colours, combined with the lack of a regular accentual framework, as a reference, creates in the listener a feeling of uncertainty, an impression of *ambiguity* regarding the articulation of the period. This feeling can be likened to what one experiences in a train, when one catches the regular rhythm of the sound of the wheels on the tracks, and then suddenly gets the impression that the period has shifted: what originally seemed like the ‘strong beat’, marking the return of the temporal cycle, turns in to the weak beat, and vice versa. The same kind of phenomenon occurs if one listens for some time to the binary ticktock of clockwork. The accent one originally attributed to the

⁷ Ibid., 49.

⁸ Simha Arom, *African Polyphony and Polyrhythm*, trans. Martin Thom, Barbara Tuckett and Raymond Boyd (Cambridge: Cambridge University Press, 1991), 229.

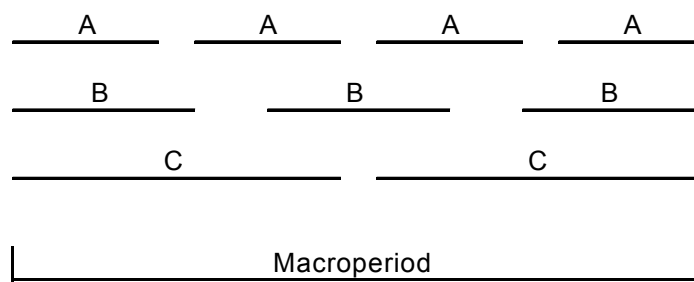
‘tick’ (TICK-tock) seems suddenly to shift on to the ‘tock’, and one hears TOCK-tick....In none of these cases, however, has the periodic cycle undergone the slightest modification; the only change has been in one’s perception of the thing, in the *Gestalt* which the mind imposes on invariant data. The regularity of the objective sound is precisely what gives rise to the feeling of uncertainty and makes a variety of interpretations possible.⁹

Arom then proceeds to define and describe the individual components that make the preceding rhythmic effects possible.

He defines the period as “a temporal loop based on the ‘repetition of similar events at similar intervals.’” In the absence of a time signature, the period acts as the temporal framework for rhythmic events in a musical work.¹⁰

A macroperiod is a cycle created from the combination of periods that are individually shorter than the whole. Specifically, the macroperiod is bounded by the point where all constituent periods simultaneously begin through the point where they all simultaneously end. Arom represents the structure of a macroperiod made up of periods A, B, and C in his Figure 1.¹¹

Figure 15: The macroperiod



⁹ Ibid., 230.

¹⁰ Ibid.

¹¹ Ibid., 231-2.

The rhythmic events in a period are cells and configurations organized in a specific manner. Arom identifies these cells and configurations of the period as rhythmic figures. A rhythmic figure is an ostinato that may be strict or varying in its repetition.¹²

The basic level of organization beneath period structures is the pulse. In any given context, the pulse is the basic unit of metric organization that defines all durations. It serves as a reference point for the ordering of rhythmic events, a common denominator for the organization of time.¹³ It is not analogous to the “beat” of the traditional measure; it is a regular succession of equal durations that does not suggest internal groupings.¹⁴

The interaction of rhythmic figures generates the composite effect of superposed periods. Arom identifies this phenomenon as polyrhythmics. He mentions two effects that come from polyrhythmics. The first is a “perpetual interweaving” that occurs when the figures are combined, and the second is “a state of permanent tension created by the antagonistic relationship among the figures.”¹⁵

Interweaving can take on two forms: strict or partial. Strict interweaving occurs when accents between two periods do not coincide; partial interweaving happens when accents occur simultaneously. Arom illustrates the two types of interweaving with a series of diagrams. The following example is number 88 from page 280, to which I have added the letters A, B, and C to represent the three percussion instruments involved:

¹² Ibid., 232-3.

¹³ Ibid., 230.

¹⁴ Maury Yeston, *The Stratification of Musical Rhythm* (New Haven: Yale University, 1976), 35.

¹⁵ Arom, 272.

Figure 16: Example 88

	1	2	3	4	5	6	7	8	9	10	11	12
A	a	a			a	a			a	a		
B			b			b			b			b
C	c				c		c				c	

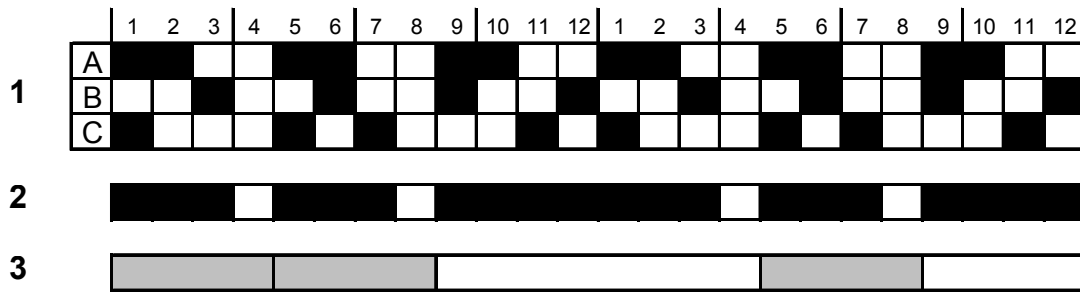
Arom makes six observations about the polyrhythms created between the three instruments in Figure 16:

- 1) A and C have a common accent in the first and fifth positions
- 2) A and B have a common accent in the sixth and ninth positions
- 3) These coincidences occur in pairs; there is not a single accent that is common to all three parts
- 4) Accents fall on ten of the twelve positions
- 5) There is strict interweaving at six positions; four are occupied by pairs of accents from two parts
- 6) This example shows that the superposition of three rhythmic figures results in two-tiered polyrhythms with the strict interweaving dominating

Figure 16 provides an efficient representation of interactions among the three periods. It is amplified to account for larger groups created by this interaction in Figure 17.

Figure 17 is divided into three tiers: Arom's original diagram stated twice with only rhythm represented for periods A, B, and C, a reduction of accented vs. unaccented positions, and blocks that represent four- and eight-unit rhythmic groups that include accents and rests. If more of the twelve-position examples were placed end-to-end, a

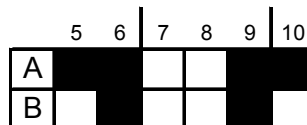
Figure 17: Larger Groups Present Within Example 88



regular alternation of four- and eight-note groups would emerge. Using Arom's example as a model, a series of reductive diagrams can show the larger audible groups that result from period interaction.

I will take this illustration one step further by isolating specific rhythms and comparing them. For example, the following figures occur in positions five, six, nine and ten between the A and B parts:

Figure 18: Rhythmically Reduced Excerpt from Example 88



If the differing timbres of the two instruments are taken into account, the second figure is the retrograde of the first. Identifying pattern-relatedness in this way is a preliminary step towards identifying larger groups.

In the listener's experience, these larger groups result from the aural synthesis of different levels of polyrhythmic activity into a whole. Arom describes this aural totality as a

...braid whose strands are fixed, both individually and with respect to one another. This braid is what someone who listens to a polyrhythmic combination takes in as a whole....We believe these strands had to be unravelled, before we could understand how such musical constructions are put together, and what kind of rules govern the arrangement of their texture.¹⁶

Even though the listener may rarely be aware of individual periods, one can perceive larger audible groups that arise from the periods' interaction. Once the individual strands have been unraveled to show the rhythmic organization of the period, the underlying patterns that give rise to the total effect are revealed.

Arom's definitions and categories of rhythmic elements in Central African music are important to a study of Reich and Ligeti's music for several reasons. First, his descriptions of African rhythms apply exactly to the musical structures found in their music both before and after they were exposed to African music. Second, the terms and concepts he provides can be used as a working terminology for an analytical method applied to Reich and Ligeti's music that seeks to clarify the effects periodicity. And third, his mention of "the *Gestalt* that the mind imposes on invariant data" is crucial to an interpretation of overlapping periods by the listener.

The compositions of Messiaen, Ligeti, and Reich may all be characterized by their rhythmic periodicity. Arom's ideas provide a framework to discuss individual components of periods and their interactions. I will include these ideas in my own analytical method to identify the different strands of rhythmic "braids" and to discuss the results of their interactions.

¹⁶ Ibid., 306.

CHAPTER 3

EXPOSITION OF THE ANALYTICAL METHOD

Any piece based on periodic structures can be broken down into a hierarchy of structural units.¹ I showed in Chapter 2 how Arom uses a hierarchy of units in order to develop a definition of polyrhythm. He defined the pulse, the rhythmic figure, the period, and the macroperiod. In the last chapter I suggested the “audible grouping” as an addition to this hierarchy. I also stated that the size of the audible grouping lies somewhere between that of the rhythmic figure and the period. I will now use the term “hyper group” to describe these larger elements that exist above the level of rhythmic figures. The collective consideration of these groups can be a clue to the larger sections and overall form of the piece.

For the purposes of my analytical method I will refine Arom’s hierarchy in the following way:

- 1) Pulse: The basic unit of metric organization that defines all durations in a given musical context
- 2) Rhythmic figures: Cells and configurations organized in a specific manner within a period; they are ostinatos that may be strict or varying in their repetition
- 3) Period: A temporal loop based on the repetition of similar rhythmic figures at similar intervals
- 4) Hyper groups: Divisions within a composite; their size is greater than that of rhythmic figures, but smaller than the period

¹ I will use the term “structural unit” to apply to any element within the periodic hierarchy.

- 5) Composites: Resulting patterns that occur when two or more periods are superposed²
- 6) Canvasses: Periods that assume a background role in relationship to a more prominent event in the music
- 7) Sections: Major divisions of a piece that may be determined by beginnings and endings of macroperiods or specific compositional techniques
- 8) Form: The large-scale structure of a piece described in terms of sections

I am using Arom's definitions (see Chapter 3) for the pulse, rhythmic figures, and period. I have provided the other definitions above as a point of reference for later discussion. In the following section I will clarify the definitions for the other five terms. I will then discuss the relationship and significance of all these terms for analysis.

Canvasses and Composites

Canvasses are periods that assume a background role in relationship to a more prominent event in the music. This background role does not reduce the significance of the canvas. I use the term canvas as an analogy to painting. Even though it is covered with paint, the canvas has a distinct set of features: color, texture, and size. The same is true with musical canvasses. Even though canvasses are secondary to other musical events, they have unique features of their own. They may contain repeated rhythmic or pitch cycles, or they may consist of two or more superposed periods. The listener may shift one's attention away from them for two reasons. Either they are repeated for a prolonged period of time (which leads to a "tuning out" by the listener) or they are played at a lower dynamic level.

² Richard Cohn uses this term in a similar manner in "Transpositional Combination of Beat-Class Sets."

Composites are analogous to the resulting patterns of Steve Reich mentioned in Chapter 1. They occur when two or more periods are superposed. Since it is often difficult for the listener to focus in on any one period, he will often listen to the periods as a whole, or as Arom has stated, as a braid made up of different strands. Once they are created and repeated, composites may assume the role of a canvas.

Composites and canvasses are ultimately defined by where the attention of the listener is directed. In Chapter 2 I quoted Arom's clock example to clarify how a listener might approach music with multiple rhythmic layers. The listener may perceive different patterns (TICK-tock or TOCK-tick) depending on her perception, even though the period has not changed. Composites and canvasses are analogous to the TICK-tock or TOCK-tick of a clock: they exist simultaneously as "invariant data" but possess different roles in the listener's perception.

The clock analogy has its limits, however. At its most fundamental level, a performance of a musical work is the realization of a composer's intent. Through the score, the composer directs the performer(s) to emphasize certain musical events above others. This emphasis typically falls into the category of melody and accompaniment, or more broadly, foreground and background events. The tick-tock sound of a clock does not have intentionality behind it. The sound of a clock is not laced with the subtleties of accents and dynamics; it simply marks the passing of time.

The changing roles of composites and canvasses are the result of a combination of compositional and listener-related factors. Part of this change is composer-directed—this may come in the form of accents, dynamics, and differences in range or timbre. The realization of the composer's intent by the performers is assumed. The other part is

listener choice—regardless of how the composer attempts to direct her attention, the listener may continue to focus on the background musical events. More often than not the aforementioned musical devices will succeed in influencing the direction of an average listener's attention.

Later in this chapter I will separate musical events into composites and canvasses in works by Reich and Ligeti. My choices will be determined by a collusion of several factors: the composer's notation, the realization of the musical work by the performers, and my perception of musical events. Even though my conclusions will not arise from the experience of multiple listeners, I believe that my approach is appropriate for the introduction of this analytical method.

Hyper groups and Sections

Hyper groups are divisions within a composite. The size of hyper groups is greater than that of rhythmic figures, but smaller than the period. Hyper groups come from the listener's interpretation of a composite; this category is, therefore, flexible and more subjective than other categories in the hierarchy. Hyper groups are often features of a composite that occur regularly. They may exist at several levels; there may be one hyper group immediately above the rhythmic figure level followed by groups derived from groups, until finally a major section of the piece is articulated.

A section may be defined by a number of musical factors. It may be a collection of similar hyper groups. Because a macroperiod occurs where the beginnings and ends of different periods coincide, it is a significant structural event and a defining element of a section. A section may also be defined by the use of a characteristic compositional

technique. For example, sections of *Six Pianos* are set apart by the use of rhythmic construction and resulting patterns.

Finally, the form of the piece stems from the relationship of the sections; there may be alternation, repetition, variation, or other methods of articulating sections that contribute to the form.

Components of the Method

My analytical method consists of three basic components. First, the piece in question must be reduced to the elements of the hierarchy above. This process can be described as deconstruction, since it is the separation of structural units from their compositional context in order to study them individually. Structural units are the “building blocks” of larger musical structures, and have differing degrees of perceptibility.

Second, the nature of the units and their relationships to one another must be observed and interpreted. Are the units identical, closely related, or completely different from one another? How do these units function collectively within the composition? What is the musical outcome of their interactions with one another? The function and interaction of these units gives way to the process that generates the aural surface.

Third, the structural units must be reassembled meaningfully in relationship to the listener’s experience. The following analyses will be the result of my experience as a listener. Further cognition studies with multiple test subjects might yield different results, but my analytical inquiry will demonstrate the application of guidelines that would direct such studies. Questions concerning the relationship of the parts to the whole must be

addressed: is the connection between unit interaction and larger musical groups perceivable, or are the musical processes that generate the aural surface obscured?

This three-fold approach to musical analysis is well suited to pieces like *Désordre* and *Six Pianos* that are based on periodic structures. While it is often possible for the listener to focus on one period, it is another matter altogether to perceive multiple periods as they progress through time, especially when two periods (pitch and rhythm) can exist simultaneously in one instrumental line. The listener synthesizes the different levels of musical information into a singular experience and often focuses on different musical events at different times within the whole. At this level, matters of hyper-structure become more important than the individual periods themselves. However, the hyper-structure would not exist at all if were not for the interactions of overlapping periods, and it is this connection that I will seek to clarify using *Désordre* and *Six Pianos* as test cases.

Désordre and *Six Pianos*

All the stylistic similarities between Reich and Ligeti stated in Chapter 2 set the stage for a meaningful musical comparison. *Désordre* and *Six Pianos* were chosen for several reasons. First, these pieces were composed at a time in each composer's career when he had been subjected to a variety of influences—African rhythmic structures in particular and non-Western practices in general. The periodic structure of these pieces flows primarily from principles of African rhythmic practice. Second, these pieces exhibit similar usages of periods: the periods overlap to create composites or to assume the role of canvasses in the experience of the listener. Finally, I have chosen these two pieces for their differences. Even though both pieces contain periodic structures, the types, lengths, functions, and interactions of these structures are quite different. I will

seek to demonstrate the flexibility of my analytical method by applying it to *Désordre* and *Six Pianos*.

CHAPTER 4

APPLICATION OF THE ANALYTICAL METHOD

I will begin my analysis of both pieces by describing their surface structure—that is, the most immediately perceivable sectional features. These features are compositional techniques that consist of pattern repetition, creation, and displacement.

I will then examine the inner workings of these techniques. My analytical method will show how the period interactions within larger sections yield a predictable hierarchy of accompanying musical structures.

Six Pianos

Before I proceed with a detailed analysis of period interaction within *Six Pianos*, I will illustrate how Reich creates its sectional divisions. According to the composer, there is a tripartite modal division in the work; the first section is in D major, the second in E dorian, and the third in B natural minor.¹ After this level of division, the sections are internally organized by a regular sequence of techniques. The first two sections of *Six Pianos* unfold according to a similar pattern:

- 1) The material that will become the canvas is introduced
- 2) Rhythmic construction gradually produces a rhythmically displaced version of one of the piano parts in the canvas
- 3) The original canvas and its displaced version combine and are perceived after repetition to create a new canvas
- 4) Resulting patterns are played against the new canvas

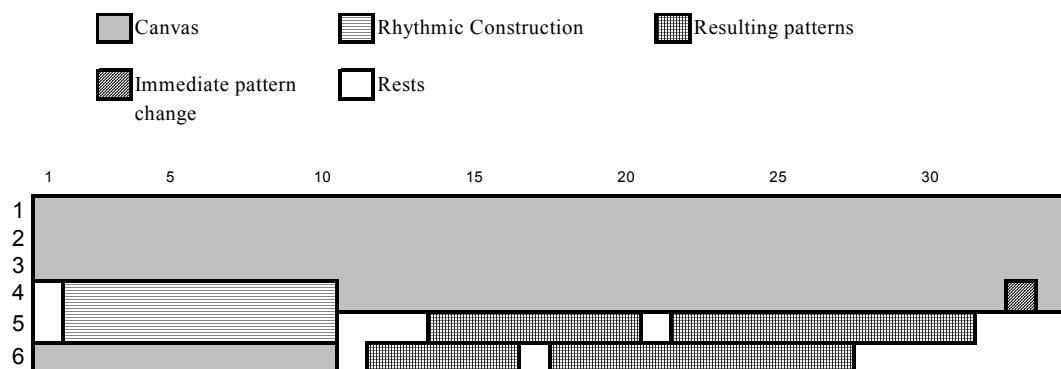
¹ Reich, “Notes from the Composer” in *Six Pianos*, Revised version (USA: Hendon Music, 1992).

- 5) Displacement in another piano part is created immediately without using rhythmic construction; this functions as a transition
- 6) This pattern becomes part of the canvas for the second rhythmic construction
- 7) Steps 1-4 are repeated to generate the second half of the section

The third section is made up of three consecutive rhythmic constructions; the resulting patterns are absent.

Figure 19 illustrates the different levels of activity in mm. 1-34, the first half of section 1. The numbers 1-6 on the y-axis represent the six piano parts; the measure numbers are found on the x-axis.

Figure 19: *Six Pianos*, mm. 1-34



I will now use the elements of my hierarchy to examine mm. 1-34 in greater detail.

Composites and Hyper groups in the First Rhythmic Construction

The pulse is articulated at all times during *Six Pianos*; there is not a moment of silence. In fact, the only rhythmic value articulated in *Six Pianos* is the audible pulse, a constant stream of eighth-notes.

Even though this piece is devoid of accents or rhythmic values longer than the eighth-note, Reich is still able to articulate different rhythms by the use of registral extremes. The pattern in Figure 20 repeats for many measures thereafter. In spite of appearing at different pitch levels among the pianos, the contour of the pattern remains the same. In Figure 20 I have juxtaposed m. 1 with a rhythmic reduction. The lower blocks in each measure reduction represent the lowest pitches of each pattern that occur on the first and sixth eighth notes (subsequently referred to as “beats”). The upper blocks represent the remaining pitches. Numbers 1-8 refer to the eight beats that comprise the measure.

Figure 20: Measure 1 of *Six Pianos*, Pianos 1-3

The figure displays the musical notation and a corresponding rhythmic reduction for the first measure of *Six Pianos*, Pianos 1-3. The notation is for three players, all in treble clef with a key signature of two sharps (F# and C#) and a common time signature (C). The dynamic marking *mf* is present for each player. A box labeled '1' is placed above the first note of Player 1. The rhythmic reduction is a grid with 8 columns representing beats and 3 rows representing players. Black blocks indicate the presence of notes.

	1	2	3	4	5	6	7	8
Player 1	Black	Black	Black	Black	Black	Black	Black	Black
Player 2	Black	Black	Black	Black	Black	Black	Black	Black
Player 3	Black	Black	Black	Black	Black	Black	Black	Black

This pattern repeats 6-10 times in m. 1 before rhythmic construction begins in m. 2. During these repetitions the notes on the first and sixth beats stand out from the surrounding texture. This is due to their lower range and to the fact that they sound together to produce a B-minor triad. In the absence of written accents, these two factors combine to produce a 5+3 beat pattern; this pattern is the first statement of a rhythmic pattern above the pulse level.

The three patterns in Figure 20 are repeated in Players 1-3 throughout the entirety of Section I (mm. 1-61). Together these patterns create a 62-measure period (the first 34 measures of this period appear in Figure 19). This period assumes a canvas role in measure 2 as the process of rhythmic construction begins.

Figure 21: *Six Pianos*, Players 1-6, mm. 2-10, First Rhythmic Construction

The musical score for Figure 21 displays the first rhythmic construction for six players (Player 1 through Player 6) across measures 2 to 10. The score is written in G major (one sharp) and 4/4 time. Measures 2-10 are indicated by a bracket at the top. The notation for each player is as follows:

- Player 1:** Treble clef. Measures 2-10: A series of eighth-note chords (B2, D3, F#3) and quarter notes (G2, A2) in a 5+3 beat pattern. Measure numbers 2, 3, 4, and 5 are boxed above the staff.
- Player 2:** Treble clef. Measures 2-10: A series of eighth-note chords (B2, D3, F#3) and quarter notes (G2, A2) in a 5+3 beat pattern.
- Player 3:** Bass clef. Measures 2-10: A series of eighth-note chords (B2, D3, F#3) and quarter notes (G2, A2) in a 5+3 beat pattern.
- Player 4:** Bass clef. Measures 2-10: A series of eighth-note chords (B2, D3, F#3) and quarter notes (G2, A2) in a 5+3 beat pattern.
- Player 5:** Bass clef. Measures 2-10: A series of eighth-note chords (B2, D3, F#3) and quarter notes (G2, A2) in a 5+3 beat pattern.
- Player 6:** Treble clef. Measures 2-10: A series of eighth-note chords (B2, D3, F#3) and quarter notes (G2, A2) in a 5+3 beat pattern.

Figure 21 (continued)

The musical score for Figure 21 (continued) consists of six staves, labeled Player 1 through Player 6. The key signature is D major (two sharps). Player 1's staff has measure numbers 6, 7, 8, and 9 above the first four measures. The notation for all players is as follows:

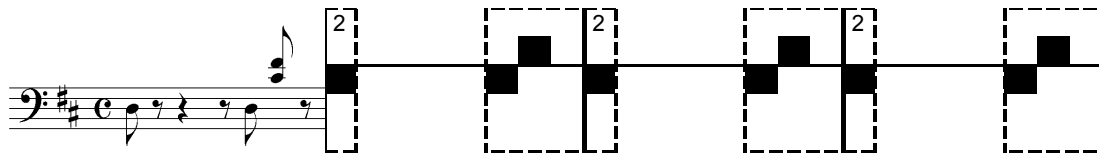
- Player 1:** Treble clef. Measures 6-9: Quarter notes (D4, E4, F#4, G4) in a descending sequence, with a repeat sign at the end of each measure.
- Player 2:** Treble clef. Measures 6-9: Quarter notes (E4, F#4, G4, A4) in a descending sequence, with a repeat sign at the end of each measure.
- Player 3:** Bass clef. Measures 6-9: Quarter notes (F#3, G3, A3, B3) in a descending sequence, with a repeat sign at the end of each measure.
- Player 4:** Bass clef. Measures 6-9: Quarter notes (G3, A3, B3, C4) in a descending sequence, with a repeat sign at the end of each measure.
- Player 5:** Bass clef. Measures 6-9: Quarter notes (A3, B3, C4, D4) in a descending sequence, with a repeat sign at the end of each measure.
- Player 6:** Treble clef. Measures 6-9: Quarter notes (B3, C4, D4, E4) in a descending sequence, with a repeat sign at the end of each measure.

Note in Figure 21 that the patterns in Players 4 and 5 are constructed one beat at a time from Player 3 until a displaced version of the pattern has been completed in m. 9. In m. 2, beat 5 of Player 3 appears as beat 7 of Players 4-5; in m. 3 beat 1 of Player 3 appears as beat 3 of Players 4-5, and so on. The pattern's entrance in m. 2 in Players 4-5 interacts with the 5+3 pattern in Players 1, 2, 3, and 6 to produce a composite pattern. Since Reich indicates that each measure of the rhythmic construction should be repeated 6-10 times, I have reproduced m. 2 four times to show the composite created from the repetition. The squares represent notes present in the initial pattern of m. 1 and its rhythmic construction. As in Figure 20, the lower squares represent the lowest note (*d*) that articulates the 5+3 pattern established in m. 1.² In subsequent figures the lower

² Octaves will be designated according to the labels C₁, C, c, c', c'', c''', c''''; c' is middle C.

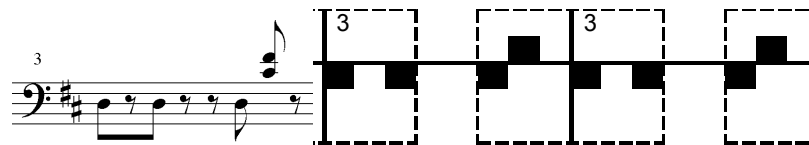
squares will also represent additional *d*'s that are added by rhythmic construction. The upper squares represent the notes *a* and above in the displaced form of the m.1 pattern. The dotted boxes show how the composite exists across barlines.

Figure 22: *Six Pianos*, m. 2 repeated



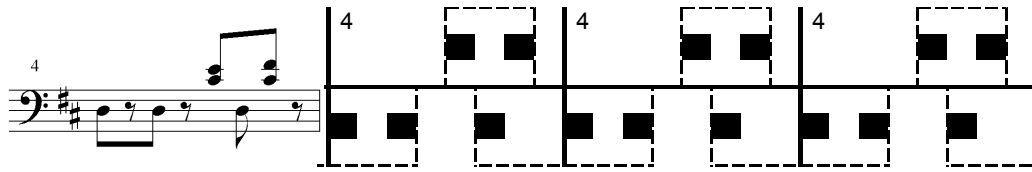
In m. 3 a *d* is added on the third beat in Players 4-5. This results in a lengthening of the composite in Figure 22 by two beats:

Figure 23: *Six Pianos*, m. 3



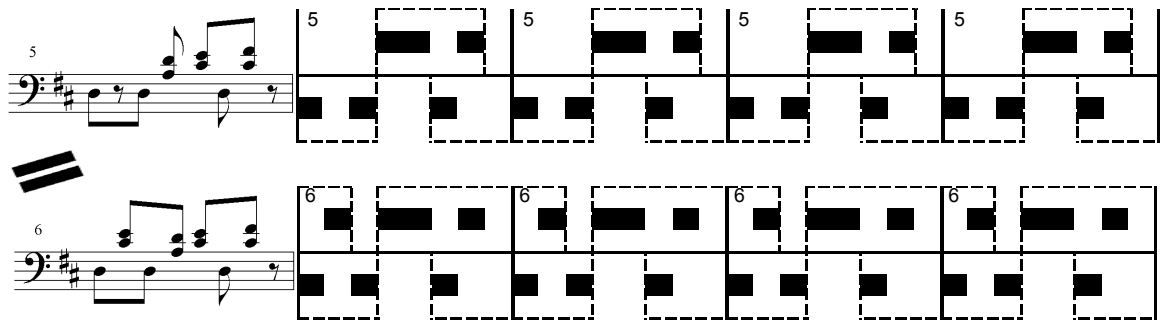
Up to this point the figures have shown that the higher and lower notes produce a composite together. In mm. 4-9, however, the addition of more notes creates a sense of independence between the upper and lower notes. The new notes coupled with the repetition exert a centrifugal force that pulls the single patterns in mm. 1-3 apart. The composites of mm. 2 and 3 diverge in m. 4 to produce two different patterns exclusive to the upper and lower parts, represented by the space inserted above and below the squares. Figure 24 illustrates this occurrence in m. 4 with the separate rhythmic figures boxed in:

Figure 24: *Six Pianos*, m. 4



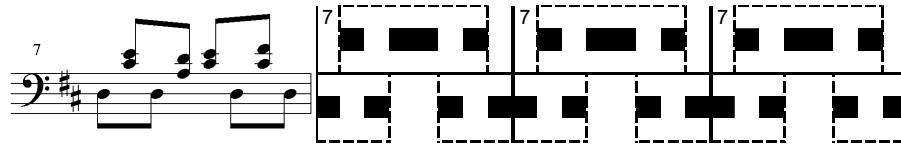
During this portion of the first rhythmic construction, the upper part consists of a rhythmic figure that grows one pitch at a time. The lower part ultimately becomes a composite that consists of the original 5+3 pattern plus the displaced 5+3. The process of addition continues in m. 5-6 with the addition of *d* and *a* on beat 4 and *c#'* and *e'* on beat 2:

Figure 25: *Six Pianos*, mm. 5-6



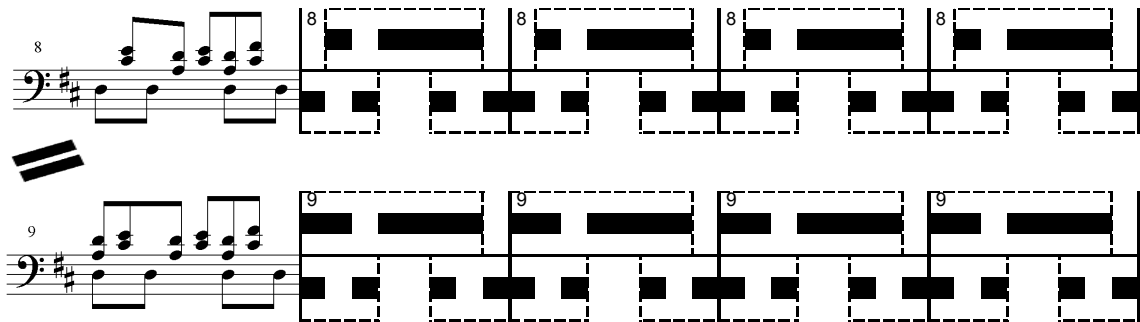
The addition of another *d* in measure 7 creates a lower rhythmic figure identical to the upper one. When this figure is created the earlier emphasis of the upper pattern changes to match that of the lower pattern:

Figure 26: *Six Pianos*, m. 7



The lower pattern continues unchanged in m. 8 and 9 while the addition of notes to the upper pattern completes the rhythmic construction.

Figure 27: *Six Pianos*, mm. 8-9



The hierarchy I discussed at the beginning of this chapter is clearly present in the first rhythmic construction of *Six Pianos*. The pulse is always audible, but *d* stands out from the pulse to create a two-part rhythmic figure of 5+3 beats. This 5+3 division exists in all the Piano parts (1, 2, 3, and 6) in measure 1. These four piano parts are the beginning of a period that lasts until m. 62. The beginning of the rhythmic construction in m. 2 sets the process of period displacement in motion. With each measure, the added beats produce new composites that in turn yield hyper groups. In mm. 2-3 the hyper groups include pitches from the upper and lower ranges. After this, the upper part is limited to rhythmic figures that stem from the gradual construction of the displaced

pattern. The lower part contains hyper groups that result from the gradual combination of two displaced 5+3 rhythmic figures.

Arom's concept of interweaving is present throughout this process. In mm. 2-7 the interweaving of the two parts is strict on every beat; no beats occupy the same position between the two parts. Measures 8-9 exhibit partial and strict interweaving since some beats of the patterns coincide while others do not. Measure 7 is particularly interesting because the patterns are identical.

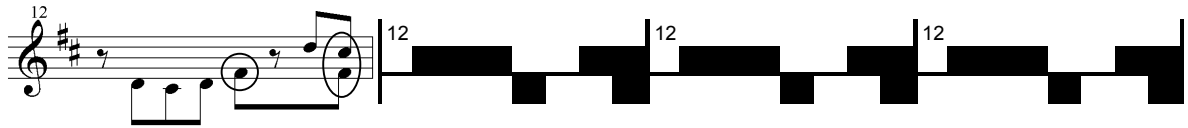
Up to this point I have analyzed hyper groups based on my perception of musical events. However, Reich as the composer directs the listener to certain composites by notating the resulting patterns. By the composer's definition, resulting patterns are constructed from pitches present within a superposition of phased patterns. This is consistent with my definition of a composite. In the next portion of my analysis I will show how hyper groups within the notated resulting patterns are identical to those encountered during the first rhythmic construction.

Reich notates four different resulting patterns in mm. 12-34. They are represented below in the same fashion as the previous figures, with the upper and lower squares representing the higher and lower pitches of the patterns.

The hyper group resulting from the pattern in m. 12 has a 5+3 beat division noted in the opening patterns of the piece. Figure 28 illustrates this in a different way than the earlier rhythmic reductions. Previously I have used upper and lower squares to correspond to higher and lower tessitura. In m. 12, the *f#*' assumes the 5+3 defining role similar to lower pitches in earlier measures. In this case the figure illustrates the roles,

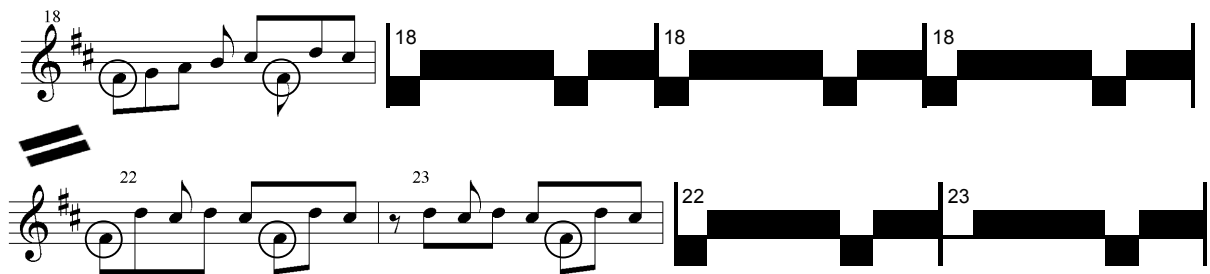
rather than the range of pitches. The d'' and $c\#''$, even though they are in pairs an octave apart, assume the same role in relation to the $f\#$'s on beats 5 and 8.

Figure 28: *Six Pianos*, m. 12



The 5+3 beat emphasis also occurs in mm. 18 and 22:

Figure 29: *Six Pianos*, mm. 18 and 22-23

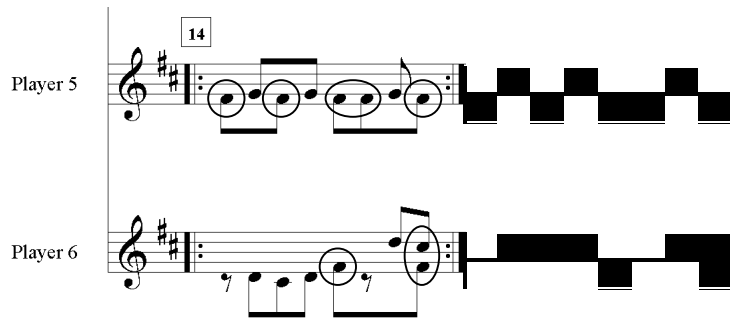


The figures above illustrate that the 5+3 (or 3+5) values in the opening measures persist throughout the resulting patterns Reich indicates.

Composites and Hyper groups of the Resulting Patterns

Now that I have demonstrated the existence of hyper groups within individual resulting patterns, I will examine how the resulting patterns interact. The first instance of simultaneous resulting patterns happens in m. 14.

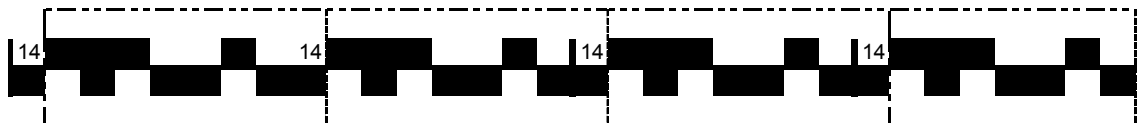
Figure 30: Players 5 and 6, m. 14



The combination of these patterns results in an enhancement of the pattern in Player 6.

The pattern in Player 6 sounds as if it is being echoed by the *f#*' on beats 1 and 6 of the pattern in Piano 5. Figure 31 is a conflation of the two figures above. I have combined the figures in this way to illustrate the echo effect achieved by the repeated *f#*' (represented in the lower blocks). The dotted lines show how the new form of the resulting pattern in Player 6 supercedes the barline by concluding on beat 1.

Figure 31: The Composite of the Resulting Patterns in m. 14



The next resulting pattern composite occurs in m. 18:

Figure 32: *Six Pianos*, Pianos 5 and 6, m. 18



Figure 33 illustrates the conflation of these two patterns.

Figure 33: The Composite of the Resulting Patterns in m. 18



The hierarchical relationships in this piece are on two levels. First, there is a surface relationship that happens in stages: the period, the period displaced against itself to create a canvas, patterns created from notes in the canvas. There is a direct generative relationship among these three elements. Second, there are similarities on a higher level of rhythmic organization, the hyper group. The group that appears in the rhythmic construction and the resulting patterns is generated from the first bar of the piece.

Désordre

Ligeti composed *Désordre* according to principles he had gleaned from African music:

In Africa cycles or periods of constantly equal length are supported by a regular beat (which is usually danced, not played). The individual beats can be divided into two, three, sometimes even four or five “elementary units” or fast pulses. I employ neither the cyclic form nor the beats, but use rather the elementary pulse as an underlying gridwork. I use the same principle in *Désordre* for accent shifting, which allows illusory pattern deformations to emerge: the pianist plays a steady rhythm, but the irregular distribution of accents leads to seemingly chaotic configurations. Another fundamental characteristic of African music was significant to me: the simultaneity of symmetry and asymmetry. The cycles are always structured asymmetrically (e. g. twelve pulses in $7 + 5$), although the beat, as conceived by the musician, proceeds in even pulses.³

The function of the pulse in *Désordre* is identical to that of *Six Pianos*. It consists

³ Ligeti, Introduction to the brochure notes for *György Ligeti Keyboard Works*, vol. 3, 10.

of eighth-notes that are always audible that have different roles. Unlike Reich, Ligeti uses accents to articulate the larger rhythmic values. Like Reich, he uses five- and three- note groups, although these groups do not persist for the entire duration of the piece.

Figure 34: *Désordre*, mm. 1-56

Molto vivace, vigoroso, molto ritmico, $\text{♩} = 63$

1 *) 2 3 4 5

f p f p f p f p f p

*)

f p f p f p f p f p

(5) 6 7 8 9

p f p *sempre sim.*

f p f p *sempre sim.*

(9) 10 11 12 13

1 2 3

(13) 14 15 16 17

Figure 34 (continued)

This musical score, labeled Figure 34 (continued), spans measures 17 to 37. It is written for a piano in the key of D major (indicated by two sharps: F# and C#) and 2/4 time. The score is organized into five systems, each with a grand staff (treble and bass clefs). Measures 17-21 form the first system, 22-25 the second, 26-29 the third, 30-33 the fourth, and 34-37 the fifth. The melody in the treble clef is characterized by eighth-note patterns, often beamed in pairs or groups of four, with frequent use of slurs and accents. The bass clef provides a steady accompaniment, primarily using eighth-note chords and single notes, also often beamed together. The overall texture is rhythmic and melodic, typical of a classical piano exercise or a short piece.

Figure 34 (continued)

This musical score is for a piano piece, continuing from Figure 34. It consists of five systems of music, each with a treble and bass staff joined by a brace. The key signature is three sharps (F#, C#, G#), and the time signature is 4/4. The measures are numbered as follows:

- System 1: Measures 37, 38, 39, 40, and 41. Measure 40 contains a triplet of eighth notes.
- System 2: Measures 42, 43, 44, and 45.
- System 3: Measures 46, 47, 48, 49, and 50.
- System 4: Measures 51, 52, 53, 54, and 55.
- System 5: Measure 56.

The notation includes various musical symbols such as eighth notes, sixteenth notes, beams, slurs, and dynamic markings like accents (>) and hairpins (<). The piece concludes with a final cadence in measure 56.

Clearly audible compositional techniques determine the sectional divisions in *Désordre* much like in *Six Pianos*. The main sectional determinant is the process of rhythmic diminution and accent frequency. Measures 1-56 gradually decrease in size from 8 beats to 4 beats. The motives that began the piece in mm. 1-8 are subjected to increasing amounts of diminution until the accents and pulse are synonymous in mm. 57-99. Measures 100-153 begins with a return to the rhythmic values of the beginning with accents dispersed as before. The process of building action, climax, and resolution yields an ABA' formal scheme. For the purposes of this study I will focus on mm. 1-56, the first "A" section, which appears in Figure 34.

Periods and Processes

Measures 1-56 are based on the interaction of two rhythmic figures in different arrangements. The figures below do not account for the split barlines in the score; instead I have used the measures in the right hand to indicate "universal measures" where the composite exists between the two hands. The right hand is represented by the upper series of squares; the left hand is represented by the lower series. The right and left hands correspond to upper and lower registers consistently throughout *Désordre*. The first rhythmic figure, which I will refer to as "a," is played by both hands in m. 1.

Figure 35: Rhythmic Figure "a," mm. 1-4, Right and Left Hands

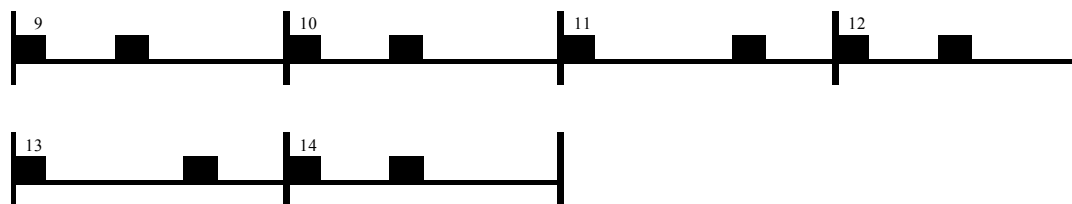


Rhythmic figure "a" becomes significant through its repetition in both hands throughout

the piece. Measures 1-4 are the starting point for separate right and left hand periods that both begin with “a.”

The second rhythmic figure is an altered form of the first with a two-measure extension. This figure first occurs in mm. 9-14 in the right hand:

Figure 36: Rhythmic Figure “b,” mm. 9-14, Right Hand



The composites and hyper groups that I will discuss below are all derived from the interaction of these two rhythmic figures and their compressed forms. Before I begin a discussion of the results of their interaction, however, I will show where these figures occur throughout the A section in Figure 37. Blank squares with the label “a” or “b” mark the beginning of the figures; the dotted lines indicate where the figures end. I have separated the series of rhythmic figures in both hands from the x-axis to show the individual patterns clearly.

Figure 37: mm. 1-56, Rhythmic Figures “a” and “b”

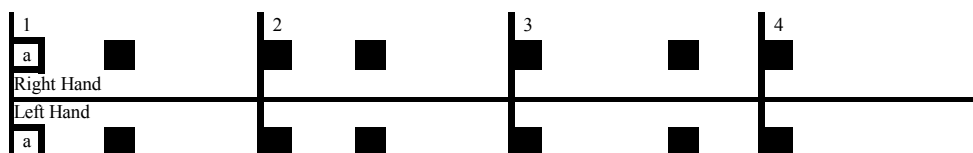


Figure 37 (continued)

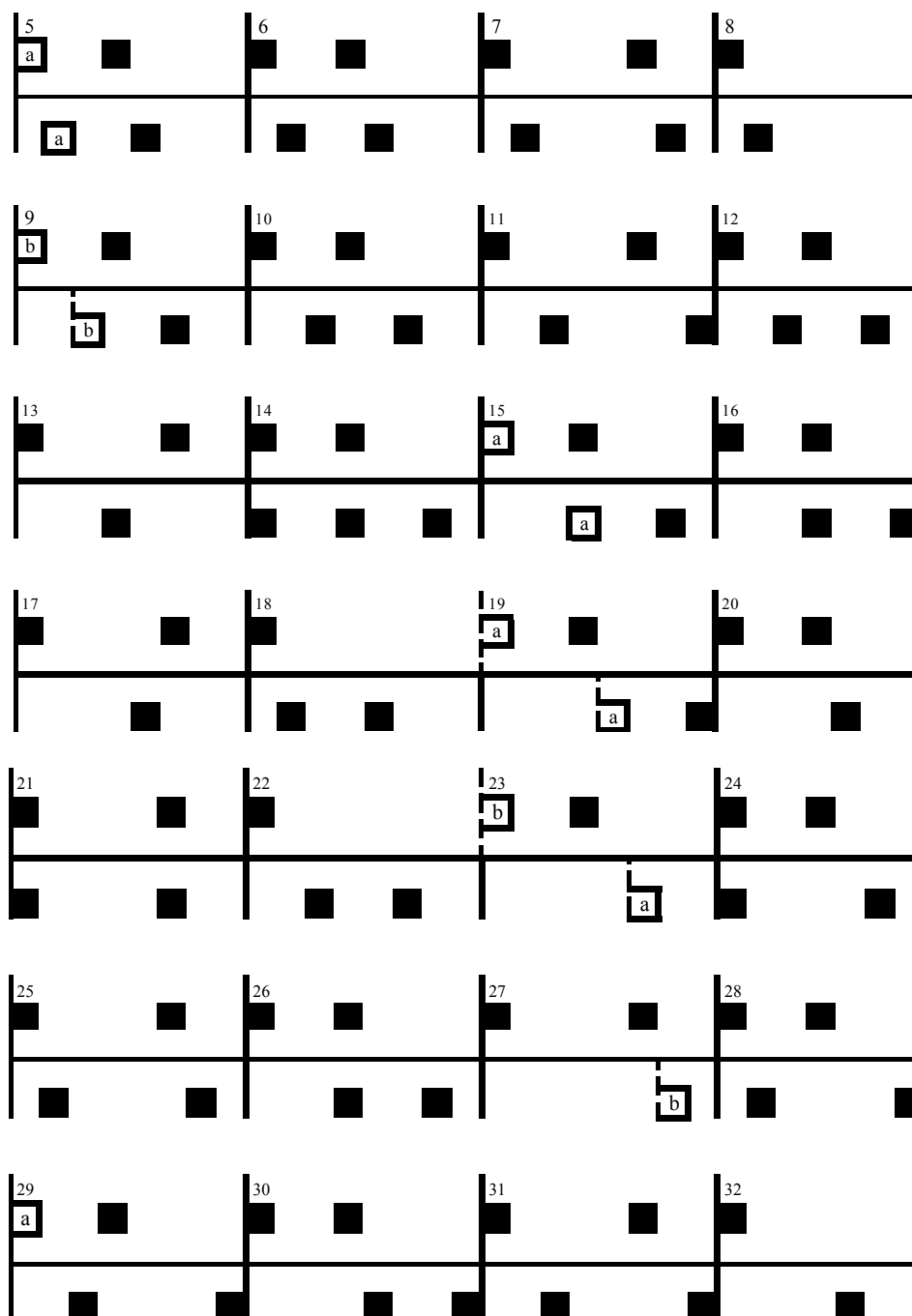
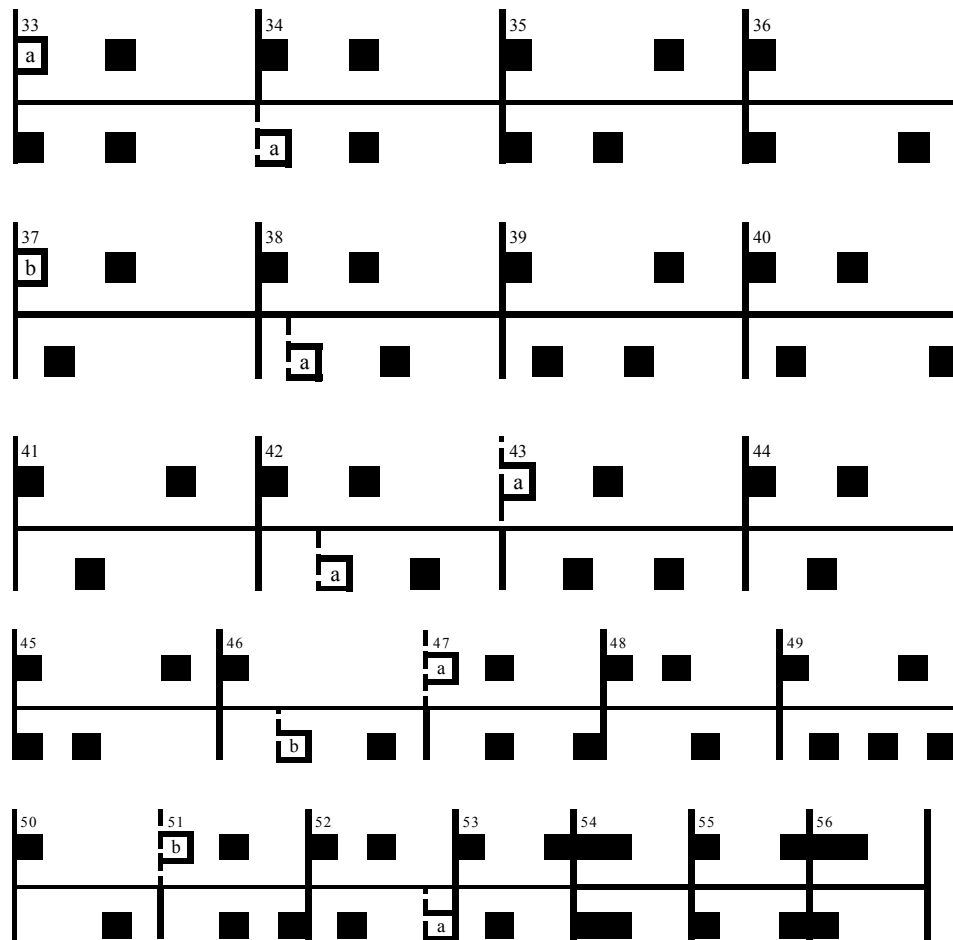


Figure 37 (continued)



The groups of rhythmic figures in mm. 1-56 will be classified as periods due to their regular patterns of alternation. Figure 38 shows the sequence of alternation in both hands. I have underlined the segments of both periods to clarify their repetitive sequences.

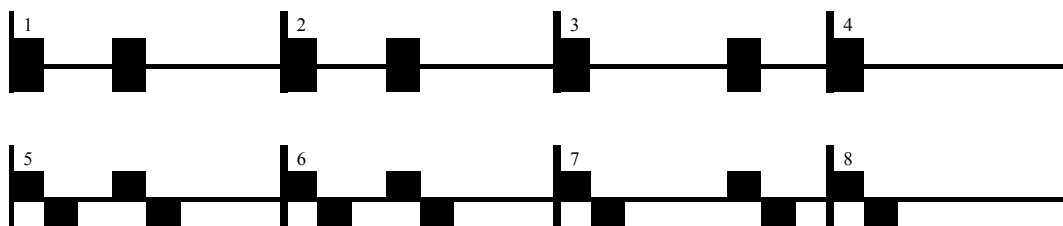
Figure 38: Alternation of “a” and “b” Rhythmic Figures in the Right and Left Hand
Periods, mm. 1-56

Right Hand: a a b a a b a a b a a b

Left Hand: a a b a a a b a a a b a

Measures 1-4 in Figure 35 establish the 3+5 and 5+3 rhythms as the primary motives of *Désordre*. This motive, as well as the subsequent surface rhythmic activity generated by period interaction, is the composite. As the two periods interact, the left hand echoes the right in increasing degrees of displacement. Figure 39 shows the beginning of the displacement between the two hands.

Figure 39: Rhythmic reduction of mm. 1-8

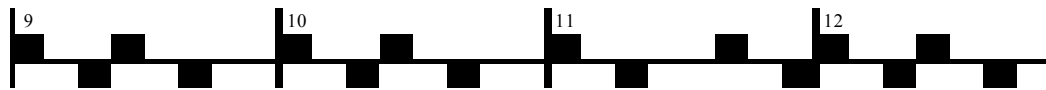


The process of displacement happens every four measures. The hands start together in m. 1 but diverge when the fourth measure of the right hand plays seven beats against the left hand’s eight beats. This process moves the two hands apart by one beat every four measures and creates hyper groups from four to six measures in length.

As I stated above, the second hyper group (mm. 4-8) sounds like an echoed repetition of the first (mm. 1-4). This ceases to be the case in the third (mm. 9-12). The hyper group in mm. 1-4 is now split by two eighth notes, but this transformation still

bears a resemblance to the original motive with its three-part division. I have illustrated this with a reduction in Figure 40.

Figure 40: *Désordre*, Composite in mm. 9-12



Hyper Groups

Consistent hyper groups emerge from the process of period displacement and beat subtraction from the rhythmic figures “a” and “b.” It will be helpful to return to the rhythmic reduction in Figure 37 with the space between the periods and the x-axis removed. In Figure 37 I emphasized the properties and locations of the periods “a” and “b.” Stated in terms of Arom’s braid analogy, Figure 37 displays the individual strands. The representation of the composite in Figure 41 allows for an easy apprehension of the entire braid and the hyper groups formed from the interaction of the strands.

Figure 41: Composite of “a” and “b,” mm. 1-56

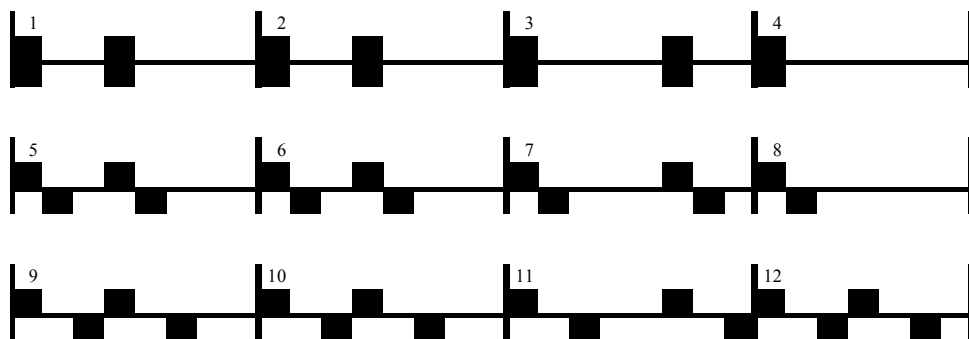
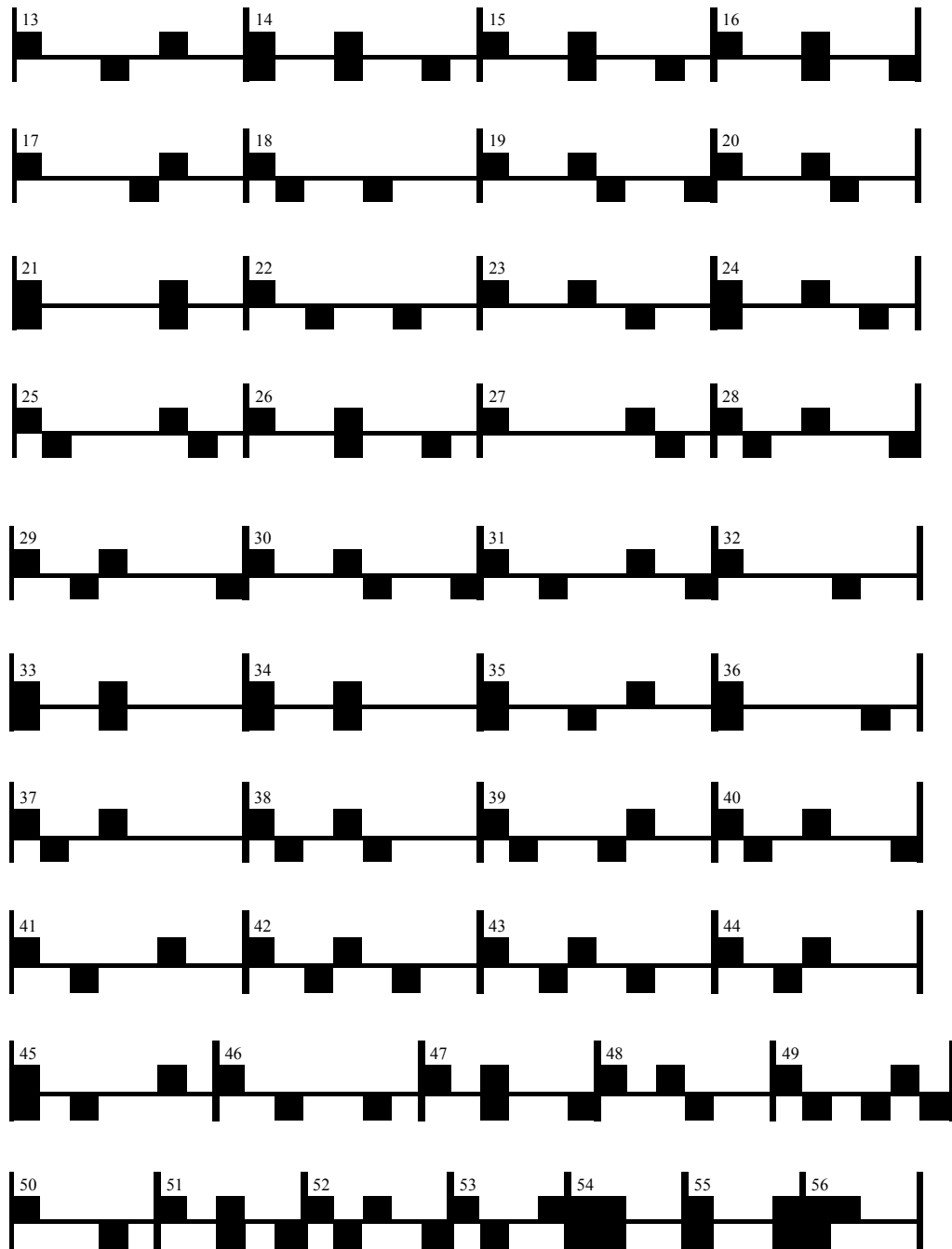


Figure 41 (continued)



The composite above can be divided into a series of hyper groups that resemble the first one. Figure 42 shows three components of the first hyper group.

Figure 42: The Three Components of the First Hyper Group, mm. 1-4



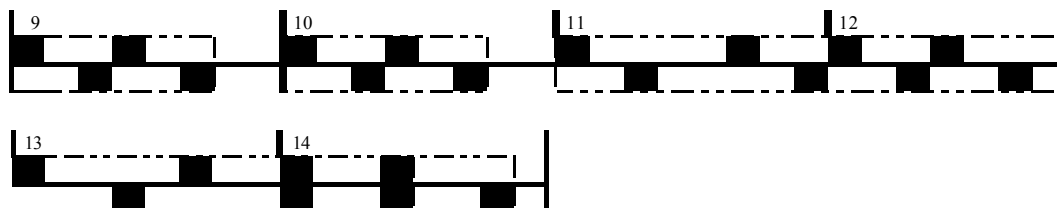
This threefold division remains constant throughout the subsequent transformations of the first hyper group. I have indicated this by my choice of measure division and the dotted lines as in Figure 42.

Figure 43: The Hyper Groups of mm. 5-50

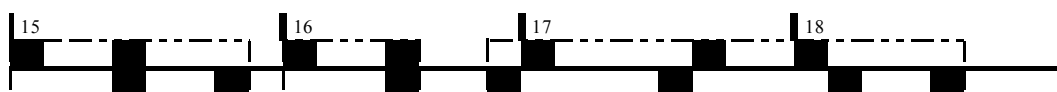
mm. 5-8



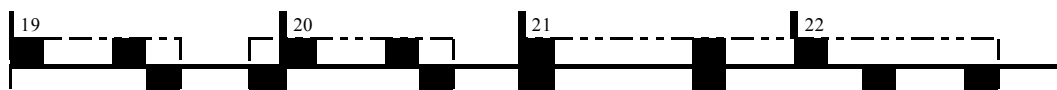
mm. 9-14



mm. 15-18



mm. 19-22

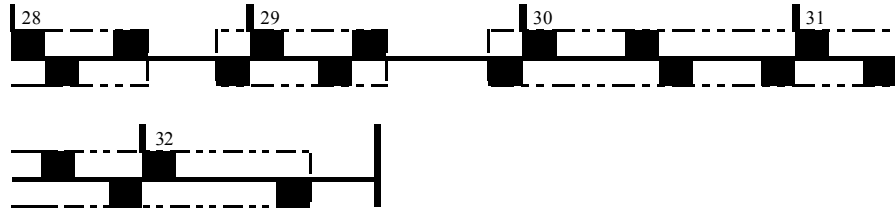


mm. 23-27

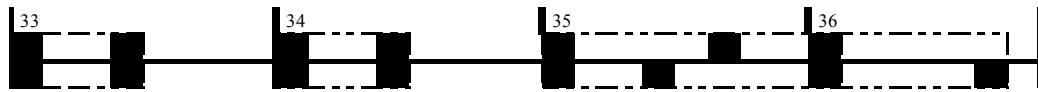


Figure 43 (continued)

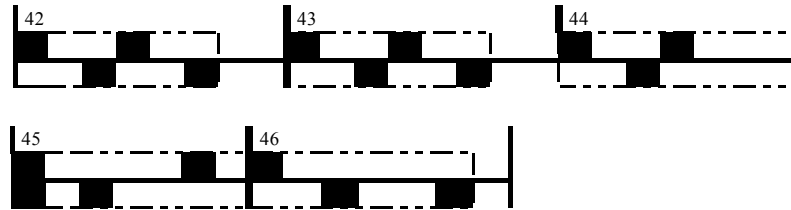
mm. 27-32



mm. 33-36



mm. 42-46



mm. 47-50



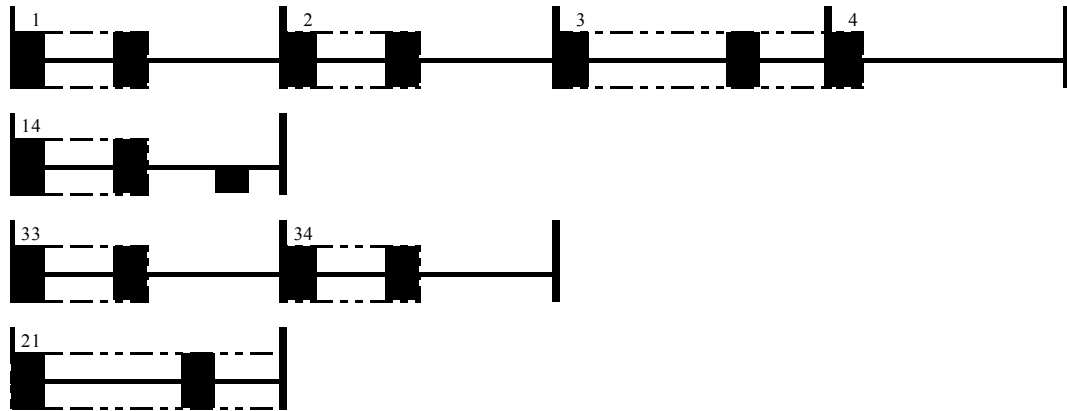
I have omitted mm. 51-56 from Figure 43 because the accented notes and the pulse are nearly synonymous.

In Chapter 3 I stated that there might be several levels of hyper groups within a given composite. In the case of the hyper groups in Figure 43, several smaller constituent hyper groups appear consistently. Beginning with the first hyper group of mm. 1-4, I will point out instances of the smaller hyper groups. For the sake of clarity, I will classify the larger hyper groups (4-6 measures long) as level 1, and the smaller, constituent hyper

groups as level 2. Figure 44 demonstrates the regular occurrence of related level 2 hyper groups related to those that first occur in mm. 1-8.

Figure 44: Level 2 Hyper Groups shared by Level 1 Hyper Groups in mm. 1-8

mm. 1-4 and related level 2 hyper groups



mm. 5-8 and related level 2 hyper groups



Some of the level 2 hyper groups can be compared to one another using terminology normally reserved for the transformation of ordered pitch class sets. In the

examples below, “P,” “R,” “I,” and “RI” stand for “prime,” “retrograde,” “inversion,” and “retrograde inversion” respectively. In mm. 13-17, this series of hyper groups appears:

Figure 45: Level 2 Hyper Groups in mm. 13-17



The second, third, and fourth hyper groups in Figure 45 are transformed in rhythm and register according to the operation of retrograde inversion. A similar example occurs in mm. 18-19:

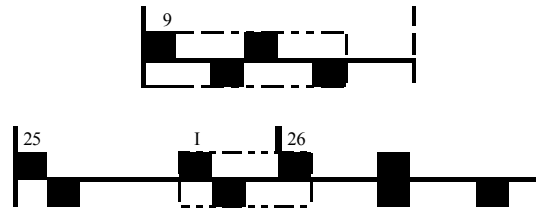
Figure 46: Level 2 Hyper Groups in mm. 18-19



Again, the relationship of the second hyper group to the first is RI.

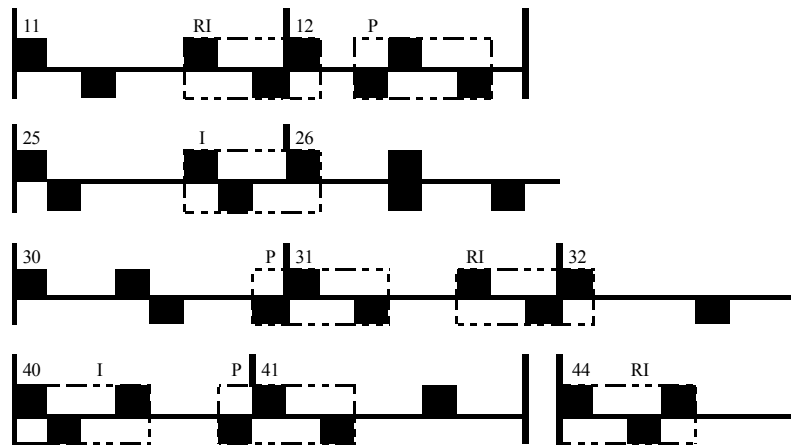
Some hyper groups become significant through repetition and transformation and can be traced back to earlier ones. To borrow again from the terminology of set theory, one such relationship is that of the subset/superset. For example, the level 2 hyper group in m. 9 is a superset in relationship to the smaller hyper group in m. 25-26. The subset in m. 9 is located on beats 3-6, and it occurs in an inverted form in mm. 25-26.

Figure 47: Subset/Superset Relationship Between Level 2 Hyper Groups in mm. 9 and 25-26



The subset is subsequently transformed in the following measures:

Figure 48: Transformations of the Subset from mm. 25-26



The examples above are transformations of the constituent elements of the level 1 hyper groups. These elements are designated as level 2 since they are smaller parts of the first series of hyper groups that comprise the composite. The level 2 hyper groups are related to one another by rhythm and range in a manner that can be described with set theory terminology.

Measures 1-56 of *Désordre* are clearly hierarchical in their structure, and my chosen terminology and classifications demonstrate this. First, I identified mm. 1-56 as the first “A” section of a ternary form in which contrast is achieved in the “B” section by

a compression of the rhythmic material in the “A” sections. As a result, the pulse and accents are synonymous in the “B” section. Second, I pointed out the repetition of two rhythmic figures, “a” and “b.” These two rhythmic figures alternated with each other in a consistent order in the right and left hands. I labeled the alteration of these figures in each hand as a period. Third, I showed that the composite of the right- and left-hand periods was generated in two ways: the strict overlap of the two periods and the beat subtraction in every fourth measure. Fourth, I pointed out the level 1 hyper groups within this composite and their resemblance to the initial motive of mm. 1-4. The resemblance of the transformations to the original creates an aural and structural coherence in this section. Finally, I highlighted the level 2 hyper groups that constitute the level 1 hyper groups in mm. 1-8. The correspondence of the different levels of rhythmic activity in mm. 1-56 of *Désordre* demonstrates a high degree of structural and aural coherence.

Chapter Summary

I chose *Six Pianos* and *Désordre* as test cases for my analytical method due to their periodic rhythmic structures. For the analysis of each piece I followed a series of steps that outlined the different hierarchical levels. The rhythmic pulse was constantly audible in both pieces, so rhythmic values were created by the emphasis of some pitches over others. This was done by changes in register, harmony, and notated accent. Rhythmic figures were the first structures to emerge from the eighth-note texture. These rhythmic figures were grouped into periods due to their repetitions. Both pieces had two or more periods happening simultaneously in varying degrees of rhythmic displacement; the interaction of these periods became the composite. The composite could be divided into a series of hyper groups. The formal structure of both pieces is governed by factors

independent of period interaction. Both pieces consist of three sections. My analysis of both pieces was limited to their first sections.

CHAPTER 5

CONCLUSIONS AND FURTHER APPLICATION

The impetus for this study began with my aural impressions of rhythmic phenomena in the music of Steve Reich. In writing this paper I set out to develop an analytical method that could explain the hierarchy of rhythmic activity that I perceived. When I was made aware of similar hierarchies in the music of Olivier Messiaen and György Ligeti, I hoped to account for a common practice of periodic music by creating terminology to label the effects of superposed periodic rhythmic structures.

I have demonstrated that rhythmic hierarchies exist in music with superposed periods. Using *Six Pianos* and *Désordre* as test cases for my analytical method, I have shown that the interactions between rhythmic periods produce predictable structures within the rhythmic hierarchies. The identification of these structures allows for a discussion of their relationships to one another. For the two pieces above, these relationships were ones in which later hyper groups were similar to the opening material in varying degrees. The terms I used to describe these structures are applicable to compositions that have varying styles of period interaction. Reich and Ligeti use different methods of determining large-scale structure in these two pieces, but the principles of period interaction are the same. The successful application of my method to two different periodic works is a model for further analyses in which periodic rhythmic structures are present.

Further Applications

A logical starting point for further analysis would be other pieces by Reich and Ligeti, such as those I discussed in Chapter 1. Using my method, one could draw

comparisons between rhythmic hierarchies in different pieces and could potentially arrive at a “common practice” of hierarchical structures for a composer’s oeuvre. The results of such a study could be used as a point of comparison to examine the work of other composers that is stylistically similar. For example, Reich’s music could be compared to music by other composers in the American minimalist school, such as Lamonte Young, Terry Riley, and Philip Glass. The influence of these composers has been manifested in the work of the so-called “post-minimalist” composers. Following aspects of musical influence from one composer to another is a possible application for my method since I have sought to identify specific rhythmic phenomena. Many genres of popular music also exhibit the minimalist influence. “Electronica,” or electronic dance music, uses repetition and pattern interaction in ways that are similar to the music of Reich and Glass.

My analysis could also account for periodic rhythmic structures in non-western musics, such as African percussion ensembles and the Balinese Gamelan, which influenced Reich and Ligeti. Perhaps a line of influence could be traced between these non-western musics and music of composers who utilize non-western techniques. My method could provide a way to discuss music from these different backgrounds with a common terminology, which in turn would make the identification of commonalities an efficient process.

I believe that my method has significant pedagogical potential as well. Students in the music theory college classroom have a low tolerance for analysis that does not have ties to their listening experience, and rightfully so. Since I formulated my method from my experiences as a listener, I believe that it is well suited for both concrete and abstract

applications. Most analyses deal in abstractions, but if they do not relate in some way to the listener's experience, their *raison d'être* is suspect.

Compositions like those I have discussed in earlier chapters would fit well in the curriculum of a college course in music theory dealing with twentieth-century music. The terminology and visual components of my method would help students to clarify the connections between structure and sound.

An analytical method must be able to clarify and systematize similar elements within bodies of musical literature (Western and non-Western) and help listeners to understand what they hear. I believe these two ideas are fundamental to music theory. Music theory is a tool for musical description and interpretation that takes as many contextual elements into account as possible (historical, philosophical, or musical) while remaining relevant to those who experience music. I have developed my analytical method with the hope that it will accomplish both of these tasks.

WORKS CONSULTED

- Aluas-Florea, Luminita. "Visible and Audible Structures: Spatio-Temporal Compromise in Ligeti's *Magyar Etudok*." *Tempo*, no. 183 (December 1992): 7-17.
- Arom, Simha. *African Polyphony and Polyrhythm*. Translated by Martin Thom, Barbara Tuckett and Raymond Boyd. Cambridge: Cambridge University Press, 1991.
- Bernard, Jonathan W. "Inaudible Structures, Audible Music: Ligeti's Problem, and His Solution." *Music Analysis* 6, no. 3 (October 1987): 207-236.
- Bernstein, David S. "Messiaen's *Quatour pour la fin du temps*: An Analysis Based Upon Messiaen's Theory of Rhythm and His Use of Modes of Limited Transposition." Ph.D. diss., Indiana University, 1974.
- Boulez, Pierre. *Orientations*. Edited by Jean-Jacques Nattiez. Translated by Martin Cooper. Cambridge: Harvard University, 1986.
- Broad, E. "A New X ? An Examination of the Aesthetic Foundations of Early Minimalism." *Music Research Forum* 5 (1990): 51-62.
- Carl, R. "The Politics of Definition in New Music." *College Music Symposium* 29 (1989): 101-114.
- Clendinning, Jane Piper. "The Pattern-Meccanico Compositions of György Ligeti." *Perspectives of New Music* 31, no. 1 (1993): 192-234.
- Cohn, Richard. "Transpositional Combination of Beat-Class Sets in Steve Reich's Phase-Shifting Music." *Perspectives of New Music* 30, no. 2 (Summer 1992): 146-177.
- Cowan, R. "Reich and Wittgenstein: Notes Towards a Synthesis." *Tempo*, no. 157 (June 1986): 2-7.
- Gann, Kyle. "Good Twin, Evil Twin; Reich and Glass: Versus or Equals?" *The Village Voice*, 23 April 1996, 60.
- _____. "Music: Let X = X (Minimalism vs. Serialism)." *The Village Voice*, 24 February 1987, 76.
- _____. "Music: Waiting for Monteverdi (Minimalism Defended)." *The Village Voice*, 21 July 1992, 86.

- Griffiths, Paul. *György Ligeti*. London: Robson Books, 1983.
- Hasty, Christopher. "On the Problem of Succession and Continuity in Twentieth-Century Music." *Music Theory Spectrum* 8 (1986): 58-74.
- Hill, Peter, ed. *The Messiaen Companion*. Portland, Oregon: Amadeus Press, 1995.
- Johnson, Tom. "Notes on New Music: The New Tonality" in *Breaking the Sound Barrier*. Edited by Gregory Battcock. New York: Dutton, 1981.
- Kivy, Peter. "The Fine Art of Repetition" in *The Fine Art of Repetition: Essays in the Philosophy of Music*. Cambridge: Cambridge University Press, 1993.
- Kramer, Jonathan. *The Time of Music*. London: Schirmer, 1988.
- Ligeti, György. Foreword to *African Polyphony and Polyrhythm*, by Simha Arom. Translated by Martin Thom, Barbara Tuckett and Raymond Boyd. Cambridge: Cambridge University Press, 1991.
- _____. *Études pour piano: premier livre*. New York: Schott, 1986.
- _____. "Mes études pour piano (premier livre): polyrythmie et création." *Analyse Musicale* 11 (1988): 44-45.
- _____. "Metamorphoses of Musical Form" in *Die Reihe 7, Formspace*. Translated by Cornelius Cardew. Bryn Mawr: Theodore Presser, 1965.
- _____. *Three Pieces for Two Pianos*. Mainz: Schott, 1976.
- _____. Introduction to the brochure notes for *György Ligeti Keyboard Works*. Vol. 3. Pierre-Laurent Aimard. SK 62308.
- _____. Introduction to the brochure notes for *György Ligeti Keyboard Works*. Vol. 6. Irina Kataeva and Pierre-Laurent Aimard. SK 62307.
- Messiaen, Olivier. *Technique de mon langage musical*. Translated by John Satterfield. Vol. 1. Paris: A.Leduc, 1956.
- Morris, P. "Steve Reich and Debussy: Some Connexions." *Tempo*, no. 160 (1987): 8-14.
- Potter, Keith. *Four Musical Minimalists*. Cambridge: Cambridge University Press, 2000.
- Reich, Steve. *Six Pianos*. Revised version. USA: Hendon Music, 1992.
- _____. "My Life With Technology." *Contemporary Music Review* 13 (1996): 13-21.

- _____. "Non-Western Music and the Western Composer." *Analyse Musicale* 11 (1988): 46-50.
- _____. "Some Thoughts About Performance." *Contemporary Music Review* 7 (1992): 39-50.
- _____. "Texture-Space-Survival." *Perspectives of New Music* 26 (1988): 272-280.
- _____. *Writings About Music*. New York: New York University Press, 1974.
- Schwarz, David. "Listening Subjects: Semiotics, Psychoanalysis, and the Music of John Adams and Steve Reich." *Perspectives of New Music* 31 (1993): 24-56.
- Schwarz, K. Robert. *Minimalists*. London: Phaidon, 1996.
- _____. "Process vs. Intuition in the Recent Works of Steve Reich and John Adams." *American Music* 8 (1990): 245-273.
- _____. "Steve Reich: Music as a Gradual Process." *Perspectives of New Music* 19 (1980-1981): 373-392.
- _____. "Steve Reich: Music as a Gradual Process, Part II." *Perspectives of New Music* 20 (1981-1982): 225-286.
- Sykes, Claire. "Fortes, Fractals, and Finger-Busters." *Piano & Keyboard* no. 196 (January-February 1999): 30-34.
- Taylor, Stephen. "Chopin, Pygmies, and Tempo Fugue: Ligeti's *Automne a Varsovie*." *Music Theory Online* 3, no. 3, May 1997 [journal online]; available from <http://www.societymusictheory.org/mto/issues/mto.97.3.3/mto.97.3.3.taylor.html>; Internet; accessed 12 April 2000.
- Toop, Richard. *György Ligeti*. London: Phaidon, 1999.
- Várnai, Peter, Josef Häusler, Claude Samuel, and György Ligeti. *György Ligeti in Conversation*. London: Eulenberg Books, 1983.
- Yeston, Maury. *The Stratification of Musical Rhythm*. New Haven: Yale University, 1976.